

# FUNCTIONAL NEUROLOGY, REHABILITATION, AND ERGONOMICS

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The aim of this interdisciplinary journal is to provide a forum for the fields of Biomedical and Rehabilitation Engineering, Neuropsychology, Clinical Neurology, Human Factors and Ergonomics, and vocational assessment and training to present critical ideas, theories, proof-of-concept for technology solutions, and data-based evaluative research to facilitate return to work or more effective functional development in children and adults.

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## Editorial

# What Should I Say? How Much Does the Patient Know of Clinical Errors?

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When making an error, legitimate or due to negligence, do most health care practitioners disclose? Not much is acknowledged about the way providers disclose those mistakes to those in their care.

A significant gap exists regarding one's necessity to be cognizant about deviation from conventional practice or simply practice errors in the context of conventional practices, with research [1-5] suggesting that fewer than half of detrimental errors are divulged to patients. This failure to reveal mistakes can diminish patient confidence and satisfaction and may increase the prospect of malpractice claims [6-11].

The reasons of this "admission gap," particularly the influence of clinician's attitudes and behaviors, are inadequately understood. Prior research [12-16] implies that while clinicians normally encourage disclosure, numerous obstacles deter them from actually speaking to patients about mistakes, such as anxiety over litigation, embarrassment, and lack of disclosure training. Physicians are also uncertain about the content of disclosure (i.e., what to say when discussing errors with patients) [17]. After errors have been made, patients usually desire a categorical statement that an error has happened, evidence about why the mistake occurred, how repetitions will be averted, and an apology [18-21]. However, in previously reported qualitative studies [17], clinicians were oftentimes guarded about discussing errors with patients, such as stating the adverse occurrence (the damage caused by medical care) but circumventing use of the word "error." Previous studies [17] also intimated that the type of error might affect disclosure. Clinicians have indicated that they would be less disposed to disclose errors that would not be obvious to the patient unless health care workers pointed out the mistake. However, patients want to be educated about all dangerous errors, not just the ones

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that are evident [20-22]. To our knowledge, no quantitative data exist regarding what information physicians would disclose and whether disclosure varies for errors that would not be apparent to patients.

The clinician's discipline may also impact how they discuss practice errors with patients. Surgeons characteristically discuss with patients the possible adverse results during the process of informed consent and with associates during morbidity and mortality meetings [23-25]. Other practitioners, however, may have less proficiency in considering adverse incidents with patients and associates. In addition, surgeons customarily advocate an "I'm in charge here" attitude in which he or she is considered responsible for mistakes made by anyone on the team, a belief slowly changing through advances in surgical education and legal policies [25, 27]. Considering specialty distinctions in disclosure could permit one group of clinicians to learn from another.

Programs to improve disclosure of mistakes to patients are increasing [29]. Success of these efforts centers on knowing better how clinicians in diverse fields consider how these challenging discussions should be had.

Appeals are increasing to fully divulge adverse events and clinical practice mistakes to patients, but not much is known about how clinicians approach disclosure [33, 36-38]. Standards provide little direction, only requiring disclosure of "unanticipated outcomes" but offering little about the type of information that should be disclosed [40].

While many situations involve unambiguous errors, many clinicians would not unequivocally apologize. For example, only 33% would unambiguously apologize, while 61% would merely express regret. Studies [41-43] in medicine and other fields recommend that individuals strongly favor clear apologies and that such explanations, while not a remedy, may avert lawsuits and encourage speedier and reduced settlements with litigation. Enlightened malpractice companies, encourage clinicians to apologize when unambiguous severe errors have injured patients [44]. The lack of agreement about whether and how to apologize following mistakes creates it probable that patient expectancies are not being realized.

Medical and surgical physicians disclose errors differently [45]. Surgeons report greater intent to divulge errors than medical professionals, but divulged less information, particularly concerning use of the word "error" and in sharing means of error deterrence. Conceivably a disclosure style has grown within surgical specialties of focusing more on the adverse event itself than on whether that incident was due to a mistake [46]. While many surgical adverse events are not due to errors, some surgical adverse events are caused by clear-cut errors [25]. An error caused by the surgeon's lack of experience with a new device, would have only 21% divulge the fact that the injury was caused by an error. The patient might reasonably assume that this adverse consequence was merely an inescapable complication. Yet, if this patient later learned from a source other than the surgeon how the injury occurred, the patient's faith and satisfaction would probably be diminished.

Many have indicated that the external malpractice environment is a key factor of disclosure [33, 47, 48]. Canadian physicians, who practice in a significantly less unfriendly malpractice environment than their US colleagues, would indeed disclose more information than US physicians [49-51]. However, in a recent survey, [3] Canadian and US patients were equally likely to report that they had not been informed about a medical error. Additionally, while medical specialists' malpractice attitudes were related to disclosure, surgeons' malpractice attitudes were not independent predictors of disclosure. Additional research should explore the complex interrelationships between malpractice issues, physician specialty, and disclosure.

Being more open with patients about errors represents a paradigm shift for clinicians. Ethicists should consider whether different dimensions of errors justify disclosing more or less information to patients about errors. By incorporating empirical research and normative analyses, the health care professions can develop guidelines for what information patients can expect from their clinical practitioners after errors. Ideally, if these guidelines can help clinicians choose their words more carefully following errors in closer agreement with patients' preferences, including apologizing and providing information about preventing recurrences, such

admission could enhance patients' confidence in the honesty and integrity of the health care system.

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# Applied Kinesiology Treatment Outcome for Emotional Distress: Replication across Samples, Therapists, Problems, Patient Age and Sex

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## Author's Note

Competing interests: The senior author, Dr. Ora Golan, is Director of the Dr. Ora Golan Institute for Emotional Immunity.

## Abstract

The current observational research reports on the impact of a novel applied kinesiology approach to the treatment of emotional distress. Treatment effectiveness, assessed on the basis of baseline to termination of therapy change in patient reported emotional distress, is assessed in three independent samples, including a randomly selected sample of patients (N = 100) and the complete series of all patients seen in 2014 (N = 661) and all patients seen in the first half of 2015 (N = 365). Findings show consistent and substantial positive treatment impact of the applied kinesiology approach to treatment of emotional distress in replications across all three samples, across patient age and sex, across diverse presenting complaints, and across multiple different therapists delivering manualized therapy. Our report concludes with discussion of directions for controlled research, following up on the current “proof of concept” evidence, in efforts to determine the comparative effectiveness of the applied kinesiology treatment approach and mechanisms of action that may explain applied kinesiology treatment impact in patients with emotional distress.

**Keywords:** Applied kinesiology, Emotional distress, Chiropractic

## Introduction

Emotional distress is common and consequential; it may be experienced as an acute or chronic condition, and it manifests in diverse experiences that can range from generalized

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fears, anxieties, and depressive thoughts to specific sexual and relationship problems to debilitating difficulties with concentration and test-taking [1-4]. Equally common are self-help attempts and professional treatment seeking by emotionally distressed individuals who are highly motivated to ameliorate their suffering, delay in treatment seeking due to stigma, and widespread experience of barriers to accessible care [5-7]. Mainstream healthcare professions including clinical psychology and psychiatry and mainstream interventions including psychotherapy and antidepressant medication are commonly offered, they are widely accepted by the help seeking public, and they prove to be variably effective in the treatment of presenting emotional complaints [8-10]. Alternative treatment approaches including acupuncture, naturopathy, chiropractic, and homeopathy are also often commonly sought in efforts to ameliorate somatic and emotional complaints, and such alternative approaches are also perceived to be variably effective in treating these problems [11-13]. While mainstream healthcare interventions are often rigorously tested in industry- or government-funded randomized clinical trials, alternative treatments are relatively rarely examined in systematic programs of carefully conducted empirical research for reasons ranging from disinterest or distrust in such methodologies to lack of funding for conducting such costly research to difficulties in effectively blinding alternative treatments [14-16].

The current observational study examines the effectiveness of an alternative approach—applied kinesiology—to the treatment of emotional distress and aims to serve as an initial “proof of concept” stage of a program of research to examine treatment impact and mechanisms of action of the applied kinesiology approach. We evaluated observations of treatment effectiveness of applied kinesiology in patients presenting with emotional distress in replications across three independent series of patients and across multiple therapists, diverse emotional presenting problems, and categories of patient age and sex. Our analysis considers

the consistency and magnitude of treatment effects and concludes with discussion of directions for controlled systematic research to determine the comparative effectiveness of the applied kinesiology treatment approach and mechanisms of action that may explain applied kinesiology treatment impact in patients with emotional distress.

## **Applied Kinesiology for Treatment of Emotional Distress**

Applied kinesiology is currently employed as a tool for identifying and treating neurologically related musculoskeletal malfunctions [17] and has been validated by numerous studies for that application [17-20]. This treatment modality employs manual muscle testing as the main diagnostic tool. Manual muscle testing typically consists of the examiner providing a context for the test, such as a specific body posture, muscle alignment, or muscle contraction. Next, the examiner applies a carefully regulated pressure on a specific muscle. The muscle's reaction to this pressure, as observed by the examiner, is interpreted in terms of neurological functioning. Muscle reaction characteristics, such as timing, duration, and smoothness, are taken as indicators of the function or dysfunction of the neurological path that controls that muscle [17, 21-22]. Correct application of applied kinesiology requires a highly experienced examiner with established knowledge of physiology as well as training in sensing the numerous characteristics of muscle reaction. It has been demonstrated that when practiced by an experienced examiner, applied kinesiology is highly accurate, reliable, and reproducible, both between examiners and within examiners [18-20, 23-24].

The application of applied kinesiology examined in this research extends the principles of applied kinesiology to the treatment of emotional distress manifested in conditions that include depressive symptoms, feelings of anxiety, and stress-related syndromes. The

technique uses muscle testing as the principal diagnostic tool. Manual muscle testing is applied after introducing a sensory environment (via visual, auditory, or other means) that provides the mental context in which the neurological system is examined. Systematic manual muscle testing is used to isolate and identify neuromuscular dysfunctions that are elicited in particularly distressing emotional contexts. Once a dysfunction is identified, restoration to normal (balanced) condition is achieved by gentle manual manipulation and visualization techniques. The technique being investigated in this study can provide a noninvasive, drug-free alternative for the treatment of many distressing emotional conditions. A detailed description of the elements of this treatment technique is found in Appendix A. The current research examines observational evidence of the effectiveness of this treatment approach in several non-selected series of patients presenting with emotional distress across independent samples, therapists, presenting emotional complaints, patient age and sex.

## Method: Study I

Study I is an observational study of the presenting baseline and post-therapy emotional distress reported by patients treated with the applied kinesiology technique for treatment of emotional distress being evaluated in this research. Primary observational endpoints include scores on baseline and post-therapy measures of patient-reported emotional distress, and the proportion of patients experiencing substantial, moderate, or no improvement in reported experience of emotional distress, as a function of participation in therapy, overall, and as a function of patient age and sex, presenting complaint, and treating therapist. These procedures were determined to be exempt from ethics review by the Research Ethics Board of the University of Western Ontario as the data consisted of anonymous observations collected for clinical treatment purposes.

## Participants

A sample of 100 patient records (36 male, 64 female) was randomly selected from case files of the first author. Data extraction included patient demographics, presenting complaints, and paired lists of patients' baseline and post-therapy reports of emotional distress. Patient ages were grouped into age categories of 18 or under (28 patients), 19-30 (27 patients), 31-45 (25 patients), and 46 and over (17 patients). Age data were missing for three case records retrieved. The nature of patients' presenting complaints appears in Table 1; we note that patients can present with multiple complaints of emotional distress and a number of these categories of emotional distress may overlap with one another.

## Assessment Instrument

A 35-item assessment instrument was administered to all patients at treatment baseline and at the end of the last therapy session. The assessment instrument asked for patient self-ratings of 35 possible emotional problems (e.g., fear of failure, difficulty dealing with authority, feeling stressed), with ratings of 0 indicating "not a problem," 1 indicating "a problem," and 2 indicating "a most severe problem." The lowest possible overall score on this scale is thus 0 and the highest possible score is 70. Patients completed baseline and post-therapy assessments by themselves and the therapist was not present when these assessments were completed.

## Statistical Analysis

Paired sample t-tests and analysis of variance were employed in the statistical analysis of these data [25].

**Table 1. Patient Complaints of Emotional Distress (Patients may present with more than one category of emotional distress and categories may overlap with one another)**

Presenting Complaint of Emotional Distress	Number	Percent
General fear, anxiety, worry, stress, social difficulties, social anxiety, difficulty among new people, fear of rejection, fear of failure, stage fright	71	71%
Learning difficulties: test anxiety, stress related to studies, failure to study, difficulty taking exams, difficulty succeeding in competitive situations, attention deficit, concentration difficulty, difficulty focusing, forgetfulness	58	58%
Lack of motivation, listlessness, lethargy, low energy, fatigue, feeling burned-out, commitment difficulties, inconsistent behavior, low self-esteem, over confidence, shyness, feeling stuck, desire to change, desire to make changes and develop self, depression, self-destructiveness, feeling stuck in work, work related stress	58	58%
Bachelorhood – unable to make connections and create relationships	33	33%
Somatic problems: allergies, hair pulling, nail biting, blinking	28	28%
Difficulties in making decisions, indecisiveness, time management difficulties, no time for self, perfectionism	25	25%
Anger, rage, impulsiveness	19	19%
Desire to be in authority, need to please others, difficulty to express self, difficulty to recognize or respect authority, difficulty to work within a framework	13	13%
Sleeping disorders, eating disorders, nutritional imbalance, weight loss/gain, desire to quit smoking	13	13%
Problem with sexual identity, sexual dysfunction, sexual pleasure difficulties, victim of sexual abuse/sexual harassment	6	6%
Wastefulness, poor money management, difficulties in earning a living	5	5%
Desire to improve relationships with family members, difficulty dealing with resistance of children to communicate within the family/household	4	4%

## Results: Study I

Patients presenting with emotional distress improved significantly from baseline (30.83) compared to post-therapy (20.94) assessments ( $P < .0001$ ), and male patients (baseline emotional distress 28.92, post-therapy emotional distress 20.5) and female patients (baseline emotional distress 31.90, post-therapy emotional distress 21.19) experienced equivalent and significant relief of emotional distress. When examined as a function of patient age category (18 and under, 19-30, 31-45, 46 and over), each age bracket reported significant baseline to post-therapy reduction in emotional distress ( $P < .0001$ , .0001, .001, .03, for age brackets, respectively), with a trend for the most reduction

in emotional distress observed in the 19-30 age bracket and the least reduction in the age 46 and greater age bracket (see Figure 1).

As can be seen in Table 2, baseline to post-therapy improvements in multiple categories of presenting complaint of emotional distress were in evidence.

Overall ratings of some level of improvement were reported by 77% (77/100) of participants; no change was reported by 1% of participants (1/100), and 22% (22/100) of participants reported some level of deterioration in their experience of emotional distress. Patients reporting some or any level of improvement were younger in age (28-29 years) than those reporting some or any level of deterioration (30.5 years),  $P < .04$ .

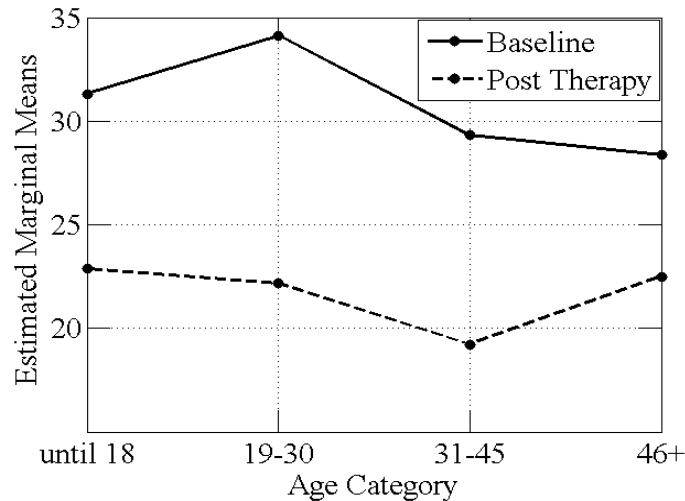


Figure 1. Baseline and post-therapy patient reported experience of emotional distress. Mean questionnaire scores before and after treatment.

**Table 2. Patient baseline to post-therapy improvement as a function of category of presenting emotional distress. (A) Difficulties in making decisions, indecisiveness, time management difficulties, no time for self, perfectionism (B) Problem with sexual identity, sexual dysfunction, sexual pleasure difficulties, victim of sexual abuse/sexual harassment (C) Desire to be in authority, suffers from the need to please others, difficulty to express self, difficulty to recognize or respect authority, difficulty to work within a framework (D) Sleeping disorders, eating disorders, nutritional imbalance, weight loss/gain, desire to quit smoking. (E) General fear, anxiety, worry, stress, social difficulties, social anxiety, difficulty amongst new people, fear of rejection, fear of failure, stage fright**

(A) Paired samples t statistics

	Mean	N	St. Deviation	Significance
Total after	22.040	25	12.0268	P < 0.0001
Total before	34.140	25	12.2606	35% Percent change

(B) Paired samples t statistics

	Mean	N	St. Deviation	Significance
Total after	18.750	6	10.5629	P = 0.17
Total before	29.500	6	12.2434	NS

(C) Paired samples t statistics

	Mean	N	St. Deviation	Significance
Total after	23.346	13	9.9234	P = 0.033
Total before	31.500	13	15.2288	26% Percent change

(D) Paired samples t statistics

	Mean	N	St. Deviation	Significance
Total after	20.545	11	12.4307	P = 0.006
Total before	32.273	11	9.6446	36% Percent change

(E) Paired samples t statistics

	Mean	N	St. Deviation	Significance
Total after	20.674	69	11.6145	P < 0.0001
Total before	32.594	69	14.0376	37% Percent change

## Methods: Study II

Study I demonstrated a consistent and substantial level of patient reported improvement in emotional distress as a function of treatment with the applied kinesiology approach, in a relatively small ( $N = 100$ ) randomly selected patient series. Study II represents an attempt to replicate this consistent pattern of treatment impact in two large series of all patients seen during extended intervals of time and explored the reliability of treatment effectiveness as a function of therapy, overall, and as a function of manualized treatment delivered by multiple therapists.

Study II is an observational study of the presenting baseline and post-therapy emotional distress reported by two independent samples of all patients with the applied kinesiology technique described earlier provided during 12-month and 6-month observational intervals. Primary observational endpoints for both samples included scores on baseline and post-therapy measures of patient reported emotional distress as a function of participation in therapy, overall, and as a function of treating therapist. The Research Ethics Board of the University of Western Ontario deemed these analyses exempt from ethics review as they involve anonymous observations collected for clinical treatment purposes.

### *Assessment Instrument: Study II*

Data extraction included patients' demographic information, non-nominal identification of the specific therapist involved in treatment delivery, and scores on three measures of baseline and post-therapy patient reported emotional distress. These three patient-reported measures were intended to provide multiple, related, convergent, and relatively stable assessments of emotional distress, and contribute equally to our outcome measure of treatment impact, as follows:

1. Patients' baseline and post-therapy ratings of emotional distress in connection with each reason for seeking treatment were assessed. At the conclusion of therapy, the therapist asked the patient to score each of his or her reasons for seeking treatment in relation to the level of emotional distress it causes, on a scale of 1 to 5, with 1 indicating that the problem caused "no emotional pain" and "5" indicating that it causes the "most severe emotional pain." The therapist did not read the patient's initial rating of emotional pain in connection with his or her presenting complaint(s).

This element of the three-component observational endpoint was scored as follows: Any presenting complaint showing a baseline to post-therapy decrease in the level of emotional pain was counted as a success and credited with one point. The number of presenting complaints with such a decrease was divided by the total number of presenting complaints, and the result, in percentage, was taken as the contribution of this component. No change or an increase in the level of emotional pain was scored as 0 – no success.

1. The patient read his or her initial description of the reasons for seeking treatment and was asked to evaluate if he or she felt an improvement. If the patient responded "yes," they were asked to describe the improvement to the therapist. Several aspects of improvement may have been relevant: frequency, intensity, degree of reaction and degree of avoidance behavior.

This element of the three-component observational endpoint was scored as follows: A "yes, the reason for seeking treatment is now improved," was counted as a success and credited with one point, a "no" answer was

counted as 0, and the number of success points was divided by the total number of reasons for seeking treatment. The result, in percentage, was taken as the contribution of this component to the treatment outcome score.

2. The patient received a paper and pencil document listing his or her treatment goals as stated at the beginning of the treatment. The patient was asked to note the presence or absence of improvement in each of the listed goals by choosing one of three 3 options: "Yes," "No," "Has not been checked." This form was completed in the waiting room by the patient alone, with the therapist not present. The option of "hasn't been checked" was applicable for problems that the patient had not had the opportunity to experience, for example, fear of flying, for a patient that had not flown post-therapy.

This element of the three-component observational endpoint was scored as follows: A "yes" answer counted as a success and credited with 1 point, a "no" answer was counted as 0, and the number of success points was divided by the number of goals that had been checked. The result, in percentage, is taken as the contribution of this component to the treatment outcome score.

Scores in the treatment outcome analysis were based on the average of these three elements, equally weighted. The result, in percentage form, was reported as the treatment's success ("percent improvement"). It was grouped into three categories: under 30% success (not including 30%), between 30% to 60% success (not including 60%) and 60% success and above. These categories were considered to denote "no success", "moderate success" and "significant success", respectively.

### *Patient Samples*

An independent sample of 661 patient records (310 male records, 351 female records), comprising the complete series of all patients seen during calendar year 2014, was retrieved from case files. Patient ages in this series ranged from 6 to 72 for males (mean age 27) from 6 to 74 (mean age 33) for females. A second independent sample of 365 patient records (194 male records, 171 female records), comprising the complete series of all patients seen during the first six months of calendar year 2015, was also retrieved from case files. Patient ages in this series ranged from 6 to 65 for males (average age 27) and from 6 to 66 (average age 34) for females. Data extraction included patient demographics, non-nominal identification of the therapist involved in treatment delivery, and the patient emotional distress endpoints noted above.

## **Results: Study II**

Overall applied kinesiology treatment outcome for the complete series of patients presenting with emotional distress in 2014 appears in Table 3, expressed as percentage improvement in patient reported emotional distress baseline to post-therapy, as described above. It can be seen that some 89% of patients reported improvement in their level of emotional distress, including 22% (146/661) who reported a moderate level of improvement in their emotional distress (30%-60% improved) and 67% (441/658) who reported a substantial improvement (> 60%) in their level of emotional distress.

Mean percentage of patient improvement in emotional distress as a function of specific therapist involved in manualized treatment delivery is presented in Fig. 2. It can be seen that individual therapists achieved percentage of patient improvement in the 70%-75% range, and therapists did not differ significantly in therapy effectiveness.

**Table 3. Percentage improvement in patient reported emotional distress, baseline to post-therapy in in complete series of patients seen 2014**

		Frequency	Percent	Valid Percent
	Up to 30%	71	10.7	10.8
	From 30% till 60%	146	22.1	22.2
	Above 60%	441	66.7	67.0
	Total	658	99.5	100.0
	Missing	3	.5	
Total		661	100.0	

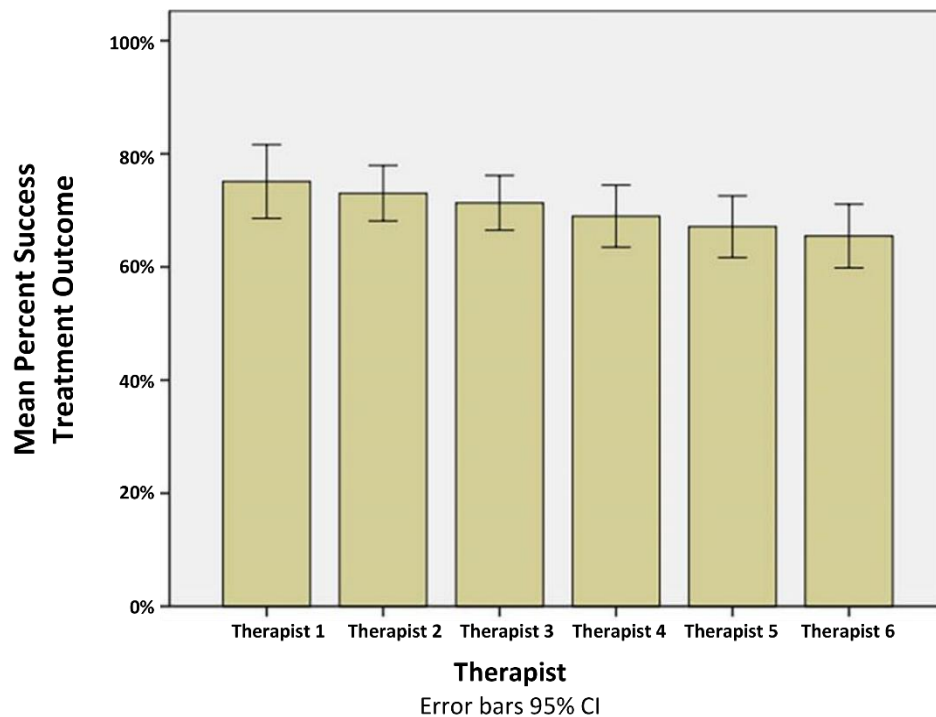


Figure 2. Mean percentage improvement in patient reported emotional distress, baseline to post-therapy, in complete series of patients in 2014 as a function of treating therapist.

Overall applied kinesiology treatment outcomes for the complete series of all patients presenting with emotional distress in the first six months of 2015 appear in Table 4, expressed as percentage improvement in patient reported emotional distress baseline to post-therapy as described earlier. It can be seen that some 87% of patients reported moderate or substantial improvement in their level of emotional distress, including 19% (70/365) who reported a moderate level of improvement in their emotional distress (30%-60% improved) and 68% (247/365) who reported a substantial

improvement ( $> 60\%$ ) in their level of emotional distress.

Mean percentage of patient improvement in emotional distress as a function of therapist involved in manualized treatment delivery is presented in Fig. 3. It can be seen that individual therapists achieved percentage of patient improvement in the 55%-73% range, and therapists did not differ significantly in therapy effectiveness save for a significant difference ( $P < .05$ ) between the least effective therapist and the other therapists.



**Table 4. Percentage improvement in patient reported emotional distress, baseline to post-therapy, in complete series of patients seen in the first six months of 2015**

	Frequency	Percent	Valid Percent
Up to 30%	48	13.0	13.2
From 30% till 60%	70	19.0	19.2
Above 60%	247	66.9	67.7
Total	365	98.9	100.0
Missing	4	1.1	
Total	369	100.0	

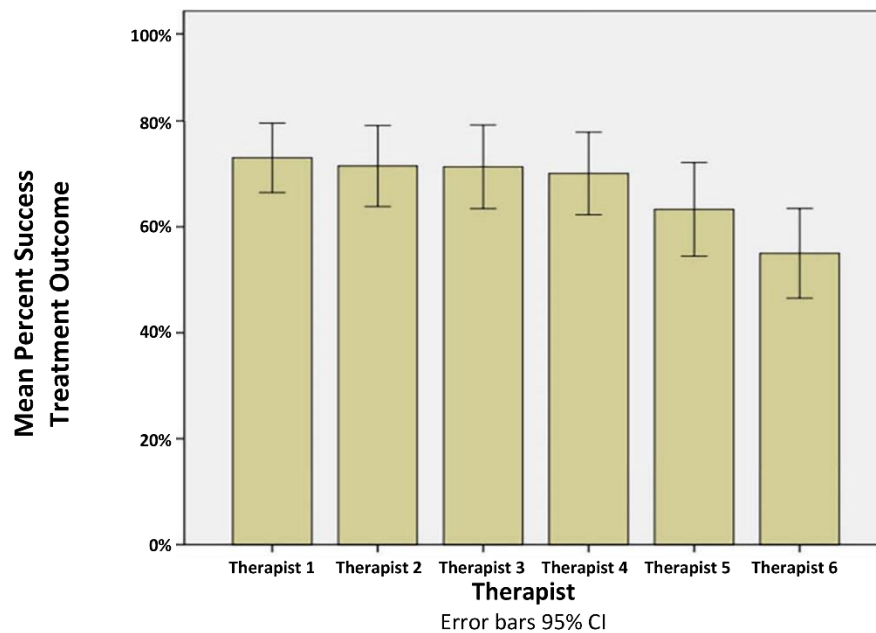


Figure 3: Mean percentage improvement in patient reported emotional distress, baseline to post-therapy, in complete series of patients in first six months of 2015, as a function of treating therapist.

## Discussion

Mainstream treatments for patients presenting with emotional distress, including psychotherapy and pharmacotherapy, have generally been the subject of rigorous government and industry funded clinical trials. While evidence of treatment effectiveness of such mainstream approaches to ameliorating emotional distress is actually quite variable, evidence-based approaches to the study of mainstream treatment outcomes are an accepted gold standard [8, 9, 26]. In contrast, rigorous evaluation of alternative therapy approaches is infrequent [14-16]. The current observational research, while not a controlled study,

replicated highly consistent evidence of patient-reported treatment effectiveness of the applied kinesiology approach articulated and manualized for the treatment of emotional distress. Across three independent samples, high levels of treatment effectiveness were reported, and equivalent and high levels of treatment effectiveness were reported by men and women, across most age ranges, across most presenting complaints, and across different therapists delivering manualized therapy.

The current replicated results may serve as a “proof of concept” and as an evidence base from which exploration of treatment effectiveness in controlled and comparator trials may be explored, together with efforts to understand treatment

mechanism of action. These results are also consistent with published reports of the reliability of manual muscle testing, a diagnostic technique related to that employed in the diagnostic technique employed in the applied kinesiology approach at focus in this therapy outcome research [27; Appendix A]. Our findings for consistent and substantial positive impact of the applied kinesiology approach to treatment of emotional distress, replicated across samples, patient age, sex, presenting complaint, and therapists, add significantly to published case reports of the impact of related treatments (e.g. Neuro Emotional Technique) on single subjects [28,29].

The current research has a number of limitations. In particular, although we were able to sample significant numbers of patients, and in two cases, *all patients* seen during periods of one year and six months, we relied upon clinical records, collected for treatment purposes, and did not use well-validated assessment scales of emotional state. While patient-reported outcomes are widely employed and indeed required for outcome assessment by the U.S. Food and Drug Administration [30,31], and employing clinical records afforded the opportunity to assess outcomes in complete series of all patients seen, validated assessments of emotional distress would have strengthened the current studies and should be employed to augment assessment in the future efforts.

Based upon the current replicated treatment effectiveness observations, an obvious, if challenging, next step will involve randomized controlled trials in which patients presenting for care will be randomized to the applied kinesiology technique or to comparator therapy - either cognitive-behavioral psychotherapy, pharmacotherapy, or combined cognitive-behavioral and pharmacotherapy. Randomized patients can be evaluated in relation to treatment effectiveness and in relation to therapeutic time and cost invested by both therapists and patients. If randomized trial research suggests consistent alternative treatment effectiveness non-inferior to or superior to mainstream therapies, in terms of treatment outcome and treatment cost, research will need to begin to explore the mechanisms of action of the applied kinesiology approach to ameliorating emotional distress. Evaluation of the impact of this at the level of the brain (via fMRI testing), at the level of endorphins and stress hormones, at the level of musculoskeletal tension, and

at the level of cognitive expectancies and symptom preoccupation and amplification, all appear to be plausible approaches to illuminating poorly understood specific processes that may be implicated in the impact of the applied kinesiology approach to emotional distress. What is important in this systematic approach is readiness to submit alternative therapeutic approaches to observational and controlled trial study in an effort to identify effective, cost-effective, and acceptable therapeutic modalities and choices for the reduction of emotional distress, guided by empirical evidence as opposed to preconceptions concerning either mainstream or alternative therapies.

## Appendix A

### *An Applied Kinesiology Approach to the Treatment of Emotional Distress*

#### ***I. Overview of Treatment Elements***

- 1) Baseline patient muscle check
- 2) Muscle check in emotionally loaded context
- 3) Questions pinpointing event that causes emotion-related muscle blockade
- 4) Emotion
- 5) Age of occurrence
- 6) Circumstances of occurrence
- 7) Eliminating emotional blockade via gentle touch and visualization
- 8) Verifying successful elimination of emotional blockade: muscle check after reintroduction of the emotionally loaded context at focus

#### ***II. Detailed Explanation of Treatment***

- 1) Muscle check

The patient is either lying on a treatment bed or sitting on a chair (not reclining). The therapist deploys a muscle test to an anterior deltoid muscle. All muscle tests during the treatment are performed on the same muscle. At the beginning of testing and treatment the muscle should be tested and found to be healthy, that is, to resist the pressure exerted by the therapist.

2) A statement, followed by a muscle test

The patient is invited to say an emotionally loaded sentence, such as "It is ok for me to fail". This statement is immediately followed by a muscle test. If the muscle tests weak it means that this statement is indeed emotionally loaded, and the emotional response of the muscle should be identified and eliminated.

3) A sequence of questions about the event creating the emotional load

After identifying an emotionally loaded context it is important to establish the circumstances of the event creating the emotional load. The therapist asks a sequence of questions aiming at pinpointing the emotion, age, and circumstances relating to this event.

- 1) Emotion: Is the emotion connected with this statement fear, threat, anger, frustration, etc.? The therapist states an emotion and immediately performs a muscle test. When the muscle tests strong the therapist continues with a different emotion. When the muscle tests weak, the emotion is connected with the event.
- 2) Age: After establishing the emotion, the age of the patient when the emotion evoking event occurred is established. First, we must establish if the event is in the past or in the present, so the first question is, for example, "Did this emotional experience start at an earlier time of your life?"

If the muscle tests weak it is taken to mean that the fear has been acquired at an earlier age and the therapist asks more questions to narrow down to a more exact age of onset of the emotional experience.

After every emotion related question, the muscle is tested. When the muscle tests weak, it means that the statement before it is the one connected with the event.

- 3) Other circumstances: After the therapist has established the emotion and the age connected with this event, other circumstances are explored, such as, for example, "Is the fear emotion at 3 years old

related to something that you had felt or experienced?" If it is not, the therapist may go on to ask "Did you absorb that feeling from a family member?"

After each statement the therapist performs a muscle test and when the muscle tests weak it means that the statement before it is the one connected with the emotion evoking event.

4) Eliminating the emotional blockade

Having acquired relevant information regarding the event causing the emotional event contributing to blockage, an elimination process is undertaken. The patient puts a hand on his/her forehead and another on the abdomen in the vicinity of the umbilicus, closes his/her eyes, and listens. The therapist asks the patient to imagine his/ her self in the circumstances of the event while the therapist drums gently on his/her forehead, inside the eyebrows. The therapist may say, for example, "Imagine yourself being two years old feeling the fear that you absorbed from your mother."

5) Retest of the emotionally loaded statement

After the neutralization, the therapist asks the patient to say again the same emotionally loaded statement as at the beginning of the treatment. If the muscle tests strong now, treatment is completed. If the muscle tests weak, the treatment is repeated. Additional events often surface and need to be eliminated. The process is repeated until the muscle tests strong after the patient repeats the statement.

### ***III. General Treatment Guidelines***

- 1) Treatment begins with patient intake. The patient provides personal details and fills out a questionnaire regarding his/her emotional condition.
- 2) In the first meeting between therapist and patient, the patient explains the problems that caused him/her to seek treatment. The information includes: How does the problem manifest itself? How long has it been a problem? How frequently does it occur? For how long and with what intensity?

The patient may list several emotional problems, and each problem is rated with a scale from 1 to 5, 1 indicating that the issue it is not a problem and 5 indicating it is a most severe problem. In addition, at this first meeting, the patient discusses treatment goals and describes what he/she would like to achieve. Lastly, the patient provides information about health problems, medicines in current use, other treatments that have been tried before and their effect, quality and quantity of sleep, and physical exercise and diet.

- 3) The treatment has a set protocol which is generic and identical to all patients. The protocol prescribes the emotion related statements that are tested and their order. The protocol does not depend on the patient's complaints; because the protocol is comprehensive it is broad enough to address the diversity of patient presenting emotional complaints. While assessment and treatment are generic, the outcome is individual to each patient. The results of addressing an emotional blockage in connection with an emotionally loaded statement such as "I am not afraid to fail", for example, may be manifested by a lower degree of fear of flying in one individual and in better relationships in another, both of whom have been affected by fear of failure, manifested in different contexts.
- 4) The treatment procedure is recorded in the patient's file methodically so that a different therapist may continue the treatment at any point.
- 5) The treatment has a preordained order of emotion evoking sentences to be tested.
- 6) The usual treatment frequency is once every two weeks, although it is possible to have them more frequently, as much as once a day. Having two or more treatments a day, however, is not recommended.
- 7) Each meeting with the therapist opens with a muscle test of the statements checked in the previous meeting. If the muscle tests strong new statements are introduced. If the muscle tests weak the treatment of this statement is repeated.
- 8) The treatment does not include other conversations or directions to the patient. The treatment is not affected by the patient's thoughts or feelings about the problem. The therapist's (or other people's) thoughts and assessment of the problem are also irrelevant and do not influence the treatment.
- 9) The treatment consists of 6 sessions, and each session concentrates on a different issue: failure, change, competition, success, not being in control, and competitiveness.
- 10) At the completion of session 4 and 6 the treatment's success is evaluated. This consists of:
  - a) Re-rating the problems presented at the beginning of treatment: the therapist reads the description of the problems provided by the patient at the beginning of the treatment, and the patient reports back about his or her current condition. The patient scores the current level of the problem on a 1 (no problem) to 5 (severe problem) scale. All of these re-rating are done without disclosure of the previous ratings.
  - b) Yes/no evaluation: The patient assesses the presenting problem(s) again, and states whether there has been improvement, this time with a qualitative description and not a quantitative rating. An improvement in a problem can also mean that the problem or the issue is not of interest anymore. For example, a patient that complained about oversensitivity to other people's opinion of him/her, having this issue removed from his/her everyday thoughts is a complete obliteration of the problem, and therefore a significant improvement. All of these re-rating are done without disclosure of the previous ratings.

- c) This patient evaluation is identical to that listed in step 2 but focuses on improvement in relation to patient specified initial treatment goals.
- 11) At the completion of the fourth session the patient can stop the treatment, or continue with two more sessions (completion of session 6). Usually it is recommended to the patient to complete the 6 sessions and most patients do.

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## Measuring Balance at High Altitudes

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### Abstract

**Aims:** Due to hypoxia and hypobaric conditions at high altitudes, oxygen saturation decreases. Ataxia might occur and the ability to maintain balance is challenged. This study aimed to determine whether a new balance assessment test, the Zur Balance Scale (ZBS) is sensitive enough to detect changes in balance at high altitudes. **Methods:** Seven healthy men, 30-64 years of age, volunteered to participate. During a 14-day journey to Mt. Everest Base Camp, Nepal, they underwent a series of balance evaluation procedures daily, using the ZBS and the single-leg balance test. In addition, physiological tests included pO<sub>2</sub> saturation (%), systolic and diastolic blood pressure (mmHg) and heart rate (pulse/min). Data on balance were collected at 4 different altitudes (2,610 m, 3,300 m, 4,400 m, and 4,950 m). **Results:** ZBS scores decreased significantly ( $P < 0.0001$ ) at higher altitudes. Heart rate was increased at higher altitudes, while systolic and diastolic blood pressure and pO<sub>2</sub> saturation decreased. **Conclusions:** Poor balance control could contribute to risk of falls from high altitudes and might result in injury or death. The ZBS detected changes in balance at high altitudes.

**Keywords:** High altitude, Balance, Blood pressure, Heart rate, Oxygen saturation

### Introduction

High altitude conditions can cause impairment in balance control that could result in falls, injury or death [1] and might trigger abnormal gait such as ataxia [2, 3] and severe headaches. These symptoms can occur due to hypoxia [4] and hypobaric phenomena, and to oxygen saturation, which decreases as altitude

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increases [5, 6]. Leptin is a biomarker in the neuroendocrine system that helps regulate homeostasis and appetite. Hypoxia, cold temperatures and hypobaric conditions affect blood leptin levels [7, 8]. This constellation of symptoms, known as Acute Mountain Sickness (AMS), occurs when the body is exposed to elevations of 2,500 m above sea level and higher. The percentage of individuals affected by altitude-related symptoms vary; thus, the incidence of AMS depends on the rate of ascent, altitude and health and age of the individual [9, 10]. Although 3-week exposure to moderate altitude had a favorable short-term effect on the cardiovascular system in patients with metabolic syndrome insulin resistance, other benefits of moderate altitude have not been reported [11]. Increased ataxia and imbalance at high altitudes were not related to AMS [12]. Changes in balance at high altitudes may also be a result of central nervous system disorders, and therefore might result in impaired balance control. Reports on the association between poor balance and hypoxia at high altitudes (>3,500 m) in open space conditions are lacking. Most measurements of balance and height have been done under laboratory conditions. However, actual field tests can provide accurate information regarding real-life situations.

The Zur Balance Scale (ZBS) is a new, validated clinical tool with no ceiling effect that is easy to conduct and inexpensive [13]. The ZBS was designed to cover the three physiological systems related to balance control: visual, vestibular, and somatosensory. Its major advantages are that it is portable, short and simple to administer (i.e., it takes approximately five minutes to complete the test and to analyze the results). Equipment needed for the test is a half-cylinder of Styrofoam 60 cm long x 18 cm wide x 9 cm high, a stop watch for measuring time in seconds and a metronome set at 60 Hz (1 beat per second). The Styrofoam density is 30 kg/m<sup>3</sup> and it is covered tightly with a piece of stretchable fabric.

This study assessed whether changes in balance control occur at different altitudes and analyzed the correlation between physiological parameters and balance control at different heights among healthy adults climbing to the Everest base camp. We hypothesized that balance control would become increasingly impaired as altitude increased. The study outcomes may have implications for commercial flight passengers and crew, military forces, trekkers, and people with known risk of falling.

## Methods

This was an observational, double-blinded study. Data were collected five times during 10 climbing days in September 2013.

### *Participants*

Seven healthy men, ages 47-64 years with normative body mass index (BMI) values, and two Nepalese Sherpas (30 and 33 years of age) volunteered to participate in the study. All participants had no symptoms (score equal zero) when the AMS questionnaire was administered at the beginning of the study.

### *Data Collection and Variables*

The following tests were administered to all participants at each altitude: AMS questionnaire [14], the Single-Leg Balance (SLB) test [15] and the Zur Balance Scale (ZBS) [13], and four physiological assessments (pO<sub>2</sub> saturation (%), systolic and diastolic blood pressure (S/DBP) (mmHg) and heart rate (pulse/min)). The total time required to finish all tests was up to 10 minutes. Tests and participant testing were administered in randomized order. Each day's tests were recorded separately to avoid comparisons with the previous results and to prevent bias.



### *Blinding*

This was a double blind study. Despite the fact that participants knew they were ascending to altitude, they were not aware of their test results. For anonymity and confidentiality, data were analyzed after concluding the journey. Participants were asked not discuss their tests during the trek. Data were only available to the statistician, who was also blinded to the assessments.

### *Questionnaire for Acute Mountain Sickness (AMS)*

The Lake Louise scoring system is a short, self-report questionnaire that was used to assess symptoms of AMS. It includes questions on headache, gastrointestinal symptoms, fatigue and/or weakness, dizziness/lightheadedness and sleeping difficulties [14].

The AMS questionnaire consists of 2 sections, a self-reported questionnaire and a clinical assessment form. A diagnosis of AMS requires the presence of the main symptom of headache and at least 1 additional symptom. Scores of 3 to 5 on the questionnaire indicate mild AMS and scores of 6 or more indicate severe AMS [16].

### *Balance Control*

Balance control was assessed with the Single-Leg Balance (SLB) test [15], and the Zur Balance Scale (ZBS) [13]. Both are valid for assessing balance control. For both tests, the participant stands two meters from the fixed target of a 5 x 5 cm X marked at eye level ( $\pm 30^\circ$ ). A solid support (such as a chair or table) is placed next to the participant for safety and confidence, while the examiner stands in front and to the side. Participants are barefoot and stand with hands on hips when ready to start. Each condition is performed twice and measured with a stop watch. The better of the two trials is recorded for analysis.

### *Single Leg Balance (SLB)*

This test was first performed with eyes open (EO) and then with eyes closed (EC), hands on hips. The participant is required to stand unassisted on one foot, while the other foot does not touch the ground. The time from when one foot is flexed off the floor until it touches the ground or the standing leg, or when an arm leaves the hips is measured in seconds. The test was conducted twice and the better of the two trials was analyzed. The maximum score is achieved by maintaining balance while standing on one foot for 10 seconds, although scores were normalized to percentages. The dominant leg was used for data collection [17].

### *Zur Balance Scale (ZBS)*

The Zur Balance Scale (ZBS) is conducted while participants stand in Romberg or tandem stance on the floor or on a small half-cylinder of Styrofoam covered tightly with a stretchable piece of fabric while completing a series of four tasks (eyes open, eyes closed, horizontal head movements and vertical head movements). Each combination of stance and task comprises a different condition (Cond), for a total of ten conditions evaluated in the ZBS [13]. The ability to maintain balance for a maximum of 10 seconds is measured for each condition.

### *Physiological Parameters*

The four physiological assessments  $pO_2$  saturation (%), systolic and diastolic blood pressure (mmHg) and heart rate (pulse/min) were measured using a finger-held pulse oximeter (Tensortip Vital Signs Monitor (VSM) (CNOGA Co., Israel). All measurements were recorded before the balance tests and after 2-3 hours of rest. The time required to conduct the physiological tests was approximately 3 minutes.

### *Timeline for Assessments*

Each participant was assessed five different times (T1-T5). Baseline assessment (T1) was taken before departure to Katmandu, Mt. Everest, Nepal (i.e., under normal oxygenation and barometric conditions) or at 1200 m above sea level for one of the Nepalese Sherpas. The second Sherpa joined the group at T2. Additional assessments from all participants were taken at altitudes T2-T5 (T2 = day 3 at 2,610 m (Phakding), T3=day 5 at 3,330 m (Namche), T4 = day 8 at 4,400 m (Dingboche), T5 = day 9 at 4,950 m (Lobuche). The exact altitudes and the elevation at each day of walking were measured by the Forerunner® 630 watch (Garmin Ltd., Schaffhausen, Switzerland).

### *Ethical Considerations*

The study was approved by the Institutional Review Board of the University of Haifa (no. 255/13). Information about the study procedure was given to all participants, who provided signed informed consent.

### *Statistical Analysis*

In order to examine the differences in measurement of various parameters along five altitude points, we employed a one-way mixed-model repeated-measures analysis of variance (ANOVA) with 1 within participant variable (altitude). The variance matrix was determined to be unstructured. Contrast analysis was used to compare successive altitudes. A P-value of 0.05 was considered significant. Statistical analysis

was performed using SAS for Windows, version 9.4.

## **Results**

### *Balance Parameters*

The higher the participants climbed, the length of time (in seconds) they were able to maintain their balance, as measured by the ZBS, significantly decreased (Figure 1). At sea level, the mean ZBS score was 87% and at 2,600 meters, the mean score decreased to 80%. At 4,400 and 4,950 meters the ZBS score decreased to 77% ( $P < 0.001$ ). SLB decreased, although the difference was not significant (Figure 2). At sea level, the mean SLB score was 70% and at 2,600 meters, the mean score decreased to 67%. At 4,400 it decreased to 55% and at 4,950 meters, the SLB score decreased to 53% ( $P < 0.651$ , NS) standard deviation ( $\pm 21.2$ -25.6).

One participant acquired AMS at 4,950 meters and was evacuated by helicopter. He was accompanied by the primary investigator.

### *Physiological Parameters*

Table 1 demonstrates the physiologic parameters at different altitudes. As altitude increased, participants' saturation decreased. Thus, at 0 m, the mean pO<sub>2</sub> saturation was 97.8%, while at 4950 m, the mean pO<sub>2</sub> saturation was 89.6%. Likewise, systolic and diastolic blood pressure decreased significantly as altitude increased. Heart rate increased in proportion to altitude.

**Table 1. Physiological parameters at different altitudes**

Altitude (m) N = Participants	0 (N = 6)	2610 (N = 7)	3300 (N = 7)	4400 (N = 6)	4950 (N = 7)	P-value
Physiological parameters						
Saturation pO <sub>2</sub> (%)	97.8 $\pm$ 1	93.4 $\pm$ 4.3	95.1 $\pm$ 2.8	91.3 $\pm$ 1.2	89.6 $\pm$ 3.3	0.0007
Systolic BP (mmHg)	122.7 $\pm$ 8.1	107 $\pm$ 17.7	106.6 $\pm$ 17	98.5 $\pm$ 21.4	98 $\pm$ 15.7	<.0001
Diastolic BP (mmHg)	75.5 $\pm$ 9.6	67.3 $\pm$ 9.9	68.9 $\pm$ 12.4	61.7 $\pm$ 10.1	63.9 $\pm$ 8.6	<.0001
Heart rate (pulse/min)	67.1 $\pm$ 8.5	74.6 $\pm$ 18.9	67.7 $\pm$ 10.3	76 $\pm$ 19.8	74.4 $\pm$ 11.4	0.0154

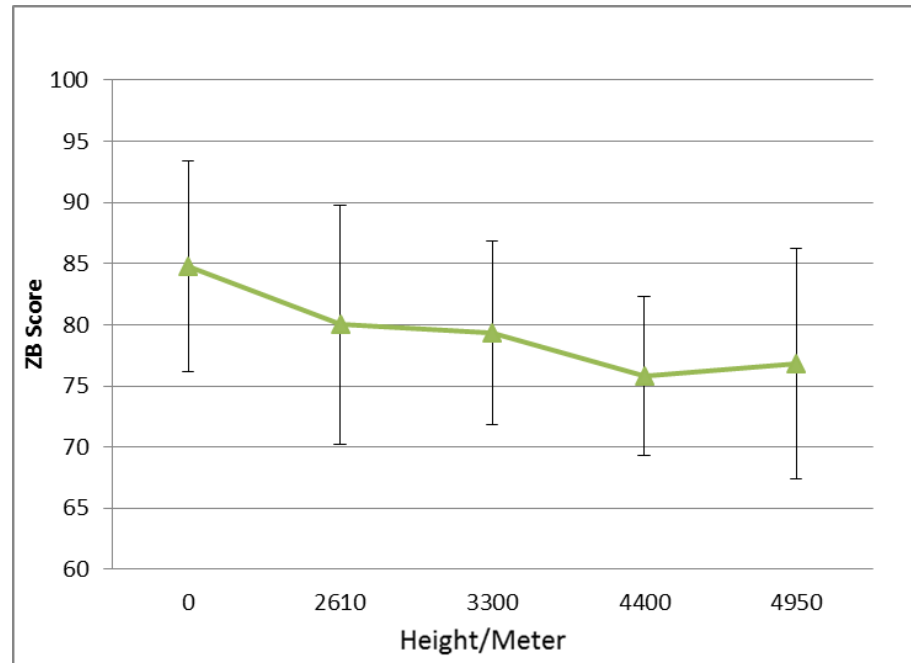


Figure 1. Number of seconds balance was maintained during the Zur Balance Score (ZBS) testing at different altitudes.

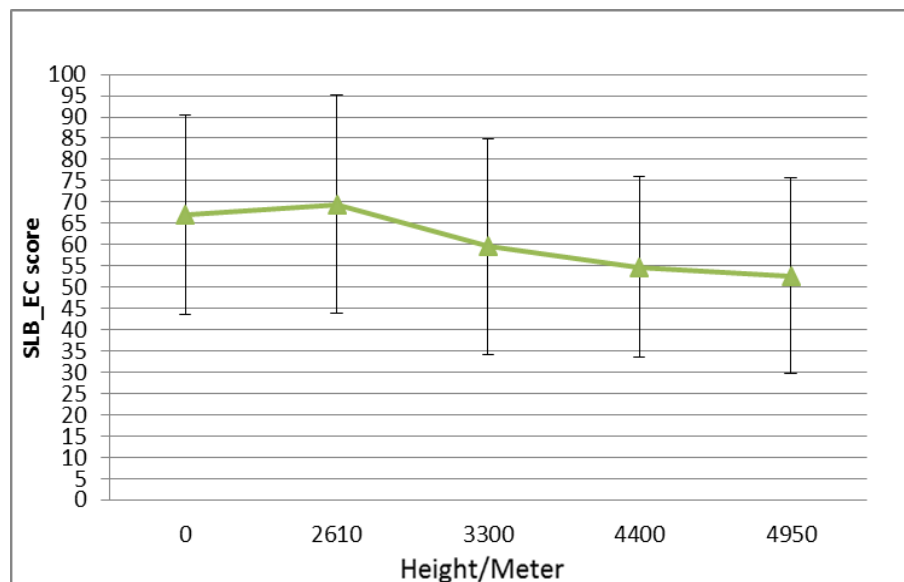


Figure 2. Number of seconds balance was maintained during the Single Leg Balance (SLB) test at different altitudes.

## Discussion

This study investigated an important mechanism involving high altitudes and balance control. The findings confirm previous reports that changes in physiological parameters such as blood pressure and

heart rate occur at moderate-to-high altitudes. In addition, we found that balance control is compromised at moderate-to-high altitudes.

It is not surprising that healthy and relatively young persons who moved from sea level to high altitudes (>3,000 m) would require some

physiological adaptations, but these individuals should expect to reach a physical fitness that is approximately 70% of their fitness capacity at sea level after a few days [18].

It is known that hypoxia results in physiological and chemical changes such as  $\text{Ca}^{2+}$  intracellular influx, release of multiple neurotransmitters and alterations in the blood-brain barrier, which induce inflammation and brain edema [19]. These can result in headache, migraine, dizziness, nausea, sleep disorders (insomnia), fatigue, and instability [20]. Symptom intensity or severity varies according to ascent rate and altitude. High level functions such as memory, reaction time and psychomotor skills are affected at altitudes above 3,500 m, and more profoundly at greater altitudes 4,500 m [21]. However, Baumgartner et al. [22] found that these AMS symptoms are not the cause of balance impairment. Even after inhaling 3 liters of oxygen, balance instabilities did not improve, although symptoms of AMS decreased significantly.

Balance control is a peripheral and central multi-sensory task which includes vision, hearing, deep and superficial sensations, peripheral vestibular system (inner ear) and central nucleus of the vestibular system, which is located in the brainstem and collaborates with the cerebellum. The results of clinical tests showed decreased ability to maintain balance in stance positions [23]. Barometric pressure, falling ambient temperature, low humidity, wind speed and even high solar radiation can lead to balance instability and falls [24, 25]. The ZBS was specifically developed based on the function of the three main systems related to balance and as such, it provides accurate information about balance control, which is indirectly associated with the vestibular system. The ZBS test was found sensitive to detect changes as altitude increased. Changes in the SLB test were not statistically significant due to large deviations between the two repeated measures. More repetitions of the test might have resulted in significant differences. However, the study design included using the better of two trials in order to prevent motor learning, which would have affected the third trial.

High altitude activities such as mountaineering and climbing are popular. Yet, it is important that

climbers as well as clinicians recognize the effect of high altitude on balance control. Individuals who expose themselves to strenuous outdoor activities at high altitudes should be aware of the risk of impaired balance. Thus, one must bear in mind that the growing popularity of mountain climbing will potentially increase the number of injuries related to falls.

## Limitations

Due to the small number of participants, the recommendations of this study are not necessarily generalizable. Data were collected only while ascending the mountain, and not while descending because the researcher had to accompany one of the participants who acquired AMS.

## Conclusion

Results of this descriptive study showed that balance control becomes compromised as altitude increases. We demonstrated that changes in altitude affect balance stability as detected by the ZBS, but not by the SLB. We suggest that all climbers should be educated properly to identify pre-existing conditions of vestibular weakness, as well as to be aware of this phenomenon. People with a vestibular system disorder might not adapt well to high altitude environments and should not participate in unsupervised mountain climbing. Further studies are needed to identify risk factors for balance instability among high altitude climbers more precisely.

## Acknowledgments

A warm thanks to those who participated in this research adventure. Thank you to CNOGA, Israel for providing the pulse oximeter for assessing blood pressure, heart rate and oxygen saturation. The authors would like to thank Dana Hadar for statistical analysis and Faye Schreiber for editing the manuscript.

### Author Disclosure Statement

The finger-held pulse oximeter (Tensortip Vital Signs Monitor (VSM) (CNOGA Co., Israel) was donated by the company. No competing financial interests exist.

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Accepted: 15 November 2016





## **IAFNR News and Events**

### **2016-2017 Conferences Related to Functional Neurology**

#### **National Institute for Brain & Rehabilitation Sciences Sponsored Events**

### **6th World Congress on ADHD**

**Date:** April 20 – 23, 2016

**Location:** Vancouver, Canada

**Contact:** Christian Reim

**Phone:** +49406708820

**Email:** [adhd@cpo-hanser.de](mailto:adhd@cpo-hanser.de)

**Event website:** <http://www.adhd-congress.org>

Dear colleagues, I am very happy to invite you to be again with us, taking part of the most global meeting on ADHD where you can share and exchange experiences and knowledge on the best strategies of diagnosing and caring individuals affected by ADHD. Our 6th World Congress on ADHD will take place from 20-23 April 2017 in Vancouver, Canada. As in keeping with tradition of the World Federation on ADHD, the scientific committee and the local organizing committee will work hard to develop a wide range of topics that will appeal to clinicians, researchers and academics stimulating the exchange of information.

#### **TOPICS**

Aetiology Autism spectrum disorder Co-morbidity Diagnosis Epidemiology Electrophysiology Etiopathogenesis Genetics Imaging studies Life quality Models, experimental Neurophysiology Non pharmacology treatment Pathophysiology Pharmacology treatment Pharmacogenetics Substance abuse Treatment Other

### **International Neuromodulation Society 13th World Congress**

**Date:** May 27 – June 1, 2017

**Location:** Edinburgh, United Kingdom

**Website:** <http://www.neuromodulation.com/inscongress>

We have chosen the title “Neuromodulation: Medicine Evolving through Technology,” to emphasize our field’s transformative force on the treatment of disease states – how it is approached now and will be approached in the not too distant future. We see almost daily reports in the mainstream media of innovation in the area of neuromodulation treating not only pain, but many conditions of the cardiovascular, neurological, gastrointestinal, urological and other systems. This meeting will mark an important time for our field.

# MOVEMENT – 2017

## Functional Neurology

### Brain, Body, Cognition

**Date:** July 9 – 11, 2017

**Location:** Oxford University, Oxford, UK

**Website:** [www.movementis.com](http://www.movementis.com)

In conjunction with Spaulding Hospital of Harvard University School of Medicine, the M.I.N.D. Institute M.I.T., the Hebrew University of Jerusalem School of Medicine, and The National Institute for Brain and Rehabilitation Sciences, Nazareth, Israel



Dear colleagues,

We have the pleasure of inviting you to attend the world conference on Movement, sponsored, in part, by the Harvard University School of Medicine's Spaulding Rehabilitation Hospital, the M.I.N.D. Institute at M.I.T., the Hebrew University of Jerusalem, the Wingate Institute for Sports and Exercise Science, the National Institute for Brain and Rehabilitation Sciences, Nazareth, Israel, the Institute for Neurology and Neurosurgery, Havana, the University of the Medical Sciences facultad 'Manuel Fajardo' Havana, the School of Public Health of the University of Havana, and Bielefeld University in Germany.

The purpose of the conference is to share knowledge of all those whose interests lie in the nature of human movement. The conference will address issues related to gait, motion, kinesiology, disorders of movement, movement rehabilitation, motion, and balance, movement and cognition, human factors and ergonomics, as well as optimized movement in elite athletes, developmental issues of movement and coordination.

Workshops on dance, dance therapy, and physiotherapy of movement impairment will also be provided.



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**ABSTRACT TOPIC AREAS**

- **Kinesiology**
  - Bipedalism as a signature of humanity
  - Factors influencing the kinds and amounts of motor performance
  - Identification of critical components of physical activity
  - Heredity and motor performance
  - Motor behavior
- **Sport and Exercise Psychology and Physiology**
- **Physical Education of Movement**
- **Coaching of Movement Effectiveness**
- **Anatomical and Physiological Fundamentals of Human Motion**
  - Neurophysiology
  - Cardiac and autonomic effects of movement
- **Therapeutic Exercise**
- **The Musculoskeletal System**
  - The skeletal framework and its movements
  - The neuromuscular basis of movement
  - Upper extremity movement – Reach and Grasp (elbow, forearm, wrist, and hand)
  - Brain and biomechanical control
  - Lower extremity movement (knee, ankle, and foot)
  - Brain and biomechanical control
- **Biomechanics of Movement**
  - Biomechanical measurement of movement
  - Conditions of linear motion
  - Conditions of rotary motion
  - Center of gravity and stability
- **Motor Skills: Principles and Applications**
  - Kinesiology of fitness and exercise
  - Moving objects: pushing and pulling
  - Moving objects: throwing, striking, and kicking
  - Locomotion: solid surface
  - Locomotion: The aquatic environment
  - Locomotion: When suspended and free of support
  - Impact
  - Instrumentation for motion analysis
- **Developmental Aspects of Movement**
  - Primitive reflexes and normal and abnormal motor development
  - Motion and developmental disabilities
  - Functional movement development across the life span
- **Movement Disorders**
  - Age related
  - Posture and balance
  - Locomotion
  - Prehension
  - Functional aspects of the basal ganglia
  - Electrophysiology of movement disorders
  - Movement disorders: structural and functional imaging
  - Genetic techniques, impact, and diagnostic issues in movement disorders

Parkinsonism: differential diagnosis  
Parkinsonism: management  
Multiple system atrophy (MSA)  
Progressive supranuclear palsy and cortico-basal degeneration  
Primary dementia syndromes and Parkinsonism  
Essential tremor and other tremors  
Dystonias  
Huntington's disease and look-alikes  
Non-Degenerative choreas  
Wilson's disease  
Tic disorders and stereotypies  
Myoclonus  
Paroxysmal movement disorders  
Hereditary and acquired cerebellar ataxias  
Drug-induced movement disorders  
Systemic disease and movement disorders  
Psychogenic movement disorders

• **Motor Control**

Sensory contributions to motor control  
Closed-loop control systems  
Vision-motor  
Audition-motor  
Proprioception and motor control  
Feed-forward influences on motor control  
Vestibular-motor  
Central Contributions to Motor Control  
Open-loop processes  
Central control mechanisms  
Central control of rapid movements  
Motor program issues  
Generalized motor programs

• **Speed and Accuracy in Movement**

Fitts' Law: the Logarithmic speed–Accuracy trade-off  
Linear speed–accuracy trade-off  
The temporal speed–accuracy trade-off  
Central contributions to the speed–accuracy trade-off  
Correction models of the speed–accuracy trade-off

• **Coordination**

• **Individual Differences and Capabilities in Movement**

• **Motor Learning**

• **Augmented Feedback**

• **Gait**

• **Rehabilitation of Motor Dysfunction**

• **Movement and Cognition**

• **Physics of Movement**

• **Physics of Dance**

• **Physics of Sports**

• **Technology and Movement Sciences**

• **Optimizing Human Motor Performance**

**WORKSHOPS**

Physiotherapy  
 Restorative and Functional Neurology  
 Kinesiology and Physical Education  
 Dance Therapy  
 Dancer's Workshop  
 Technology Workshops for Rehabilitationists  
 Cognitive Movement Therapy

**ABSTRACT SUBMISSION INSTRUCTIONS**

You can participate in the conference as a delegate, although we encourage you to submit an abstract. Please, read the following instructions carefully before submitting your abstract. Only abstracts submitted in English will be accepted.

Full papers of accepted abstracts will, pending additional review, be published in a special issue of the journal *Functional Neurology, Rehabilitation and Ergonomics*. Details will follow after acceptance of the submitted conference abstracts.

- Submit your abstract in Microsoft Word format.
- Authors' names should be provided in the format Alvarez, RS. Do not add Dr. Prof. Mr., Mrs., etc.
- The title should have a maximum of 150 characters, typed in capitals.
- Affiliation should be included in line a. If authors' affiliations are different, you should indicate them filling b, c, and d lines.
- The presenting author's email address must be included.
- The abstract should have a maximum of 350 words. Any longer and the abstracts will not be accepted.
- Indicate whether the abstract is intended for oral or poster presentation or either.
- The abstract should be structured using the following headings: Objective, Methods, Results, Conclusions, and Keywords (no more than four keywords).
- The abstract should be as informative as possible, including statistical evaluation.
- Statements such as "results will be discussed" or "data will be presented" are not acceptable.
- Standard abbreviations such as: PVS, MCS, EEG, MEEG, MRI, etc., may be used. Others should be described in full when first mentioned, followed by the abbreviation in parenthesis.
- Tables may be included, but not photographs, figures, or references.
- You will be notified via e-mail to confirm that your abstract has been received.
- If you do not receive a confirmation within two weeks, please contact the Symposium Secretariat.
- The Scientific Committee will review all abstracts.
- Some very high quality abstracts offered for oral presentation might be included in satellite symposium or courses.
- Deadline for submission of abstracts: Apr. 15, 2016
- Notification of Accepted Abstracts: Jul. 15, 2016
- Full papers submitted for review: Oct. 15, 2016
- Abstracts and full papers are to be submitted directly to the head of the conference's scientific committee: [g.leisman@alumni.manchester.ac.uk](mailto:g.leisman@alumni.manchester.ac.uk)

**Society for Neuroscience 2017 Annual Meeting**

**Date:** November 11 – 17, 2017

**Location:** Washington D.C., United States

**Website:** <http://www.sfn.org/annual-meeting/past-and-future-annual-meetings>

Neuroscience 2017 is the premier venue for neuroscientists to present emerging science, learn from experts, forge collaborations with peers, explore new tools and technologies, and advance careers. Join more than 30,000 colleagues from more than 80 countries at the world's largest marketplace of ideas and tools for global neuroscience.

## Society for Neuroscience 2018 Annual Meeting

**Date:** November 3 – 7, 2018

**Location:** San Diego, United States

**Website:** <http://www.sfn.org/annual-meeting/past-and-future-annual-meetings>

Neuroscience 2018 is the premier venue for neuroscientists to present emerging science, learn from experts, forge collaborations with peers, explore new tools and technologies, and advance careers. Join more than 30,000 colleagues from more than 80 countries at the world's largest marketplace of ideas and tools for global neuroscience.

## Recent Conference Presentations

1. Leisman, G. Optimization Methodology and Functional Connectivities Inform the Cognitive Modifiability in the Rehabilitation of Developmental Language Difficulties [Invited Plenary Paper presented at the Conference on Cognitive Modifiability, Jerusalem, Israel 3-5 June 2013]. ([http://www.brainconvention.org/en/index.php?page\\_id=48](http://www.brainconvention.org/en/index.php?page_id=48))
2. Leisman, G. If It Is Localization then There Is No Development, Education, & Rehabilitation: It's the Networks Silly. [Invited Plenary Paper presented at the 4th Conference of the International Association for Functional Neurology, and Rehabilitation, 10-13 October, 2013 Phoenix, AZ].
3. Leisman, G., Machado, C., Melillo, R. The Development of Fetal And Neonatal Consciousness [Invited Plenary Address, VI International Conference on Brain Death and Disorders of Consciousness, 3-6 December, 2013] (<http://www.komascience-cuba.com/>)
4. Leisman, G. & Muallem, R. Brains, Bilinguals, and Functional Connectivities: Neural Networks Play Out in the Classroom. [Invited Speaker Oxford Education Research Symposium at St. Edmund Hall, Oxford University. 25-26 March 2014] (<http://www.oxford-education-research-symposium.com/>)
5. Leisman, G. Functional Connectivities and Re-connectivities Reflect Cognitive Modifiability in Neurorehabilitation. [Invited paper presented at the Second Annual Conference in Rehabilitation Medicine, Baltimore, MD USA 1-16 July 2014]. (<http://dx.doi.org/10.4172/2329-9096.S1.006>)
6. Leisman, G. Optimization Models for Quantifying Visual Search Scanpath Efficiency: Measuring Treatment Recovery in Traumatic Brain Injury. [Invited paper presented at the Second Annual Conference in Rehabilitation Medicine, Baltimore MD, USA 1-16 July 2014]. (<http://dx.doi.org/10.4172/2329-9096.S1.006>)
7. Leisman, G., Gilchrist, J., Rodriguez-Rojas, R., Estevez, M., Machado, C., Kaspi, M., Melillo, R. A Method for Quantifying Visual Search Scanpath Efficiency in Elucidating Cognitive Status Post Traumatic Brain Injury. [Paper presented IEEE-Israel, Eilat, Israel 2-5 December, 2014].
8. Leisman, G., Rodríguez Rojas, R., Batista, K., Carballo, M., Morales, J.M., Iturria, Y., Machado, C. Measurement of Axonal Fiber Connectivity in Consciousness Evaluation. [Paper presented IEEE-Israel, Eilat, Israel 2-5 December, 2014].
9. Leisman, G. The Coincident Decline of Movement and Cognitive Ability: Movement Sciences in the Aid of Public Health Policy Intervention. [Paper presented at the 4th International Conference on Pediatric Disease, Disability and Human Development, 20-23 January, 2015, Jerusalem Israel]

10. Mualem, R., Leisman, G., Mograbie, S.K., Boshnak S. Brain-Based Learning during Preschool: An Underused Window of Opportunity. [Paper presented at the 4th International Conference on Pediatric Disease, Disability and Human Development, 20-23 January, 2015, Jerusalem Israel]
11. Leisman, G. Machado, C. Thinking, Walking, Talking: The Development of Integratory Brain Function [Paper presented as part of a Symposium on Movement and Thought at the International Convention of Psychological Sciences, Amsterdam, The Netherlands, 12-14 March, 2015]
12. Leisman, G. and Braun-Benjamin, O. Symposium on Movement and Thought at the International Convention of Psychological Sciences, Amsterdam, The Netherlands, 12- 14 March, 2015]
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## Literature Calling

### A Survey of Recent Publications of Interest to Functional Neurology

#### Olympic Athletes Are Electrifying Their Brains, and You Can Too

If a brain-stimulation gadget catches on, expect controversy over “brain doping”

Posted 23 Aug 2016 | 15:00 GMT

IEEE Spectrum

By Eliza Strickland

It's a chilly mid-April morning in the Silicon Valley suburb of Menlo Park. The sun climbs wanly above the horizon while techies start up their Teslas and baristas fire up their espresso machines. I'm far removed from my own morning rituals as I shiver in my workout clothes and stride toward a training facility for elite athletes, my mind a jumble of anticipation and curiosity—with just a twinge of apprehension.

In a few minutes, a technician will place a new gadget called Halo Sport on my head, and the seemingly ordinary headphones will send a trickle of electric current into my brain's motor cortex. That current will stimulate the neurons that send movement commands to my muscles, supposedly making my brain better at transmitting those commands. According to the San Francisco startup behind this device, Halo Neuroscience (<https://www.haloneuro.com/>), pairing the stimulation with physical training can give an athlete the winning edge. The company says its product can make people faster, stronger, more nimble, or better coordinated.

The Halo isn't on the market yet, but it's already being used in elite athletics—a world where a vanishingly small improvement in performance can mean the difference between finishing first or eighteenth. Some Olympic athletes, including sprinters and swimmers, used a premarket version of the Halo to prepare for the Rio games (</the-human- os/biomedical/devices/olympic-athletes-try-zapping-their-brains-to-improve-sports-performance>). Professional basketball, baseball, and American football teams are also experimenting with it; the company declines to identify those teams, but one basketball player with the Golden State Warriors tweeted a photo (<https://twitter.com/jamesmcadoo/status/709956211983175680>) of himself wearing the gear. The first batch for general consumers, scheduled for shipment in October, sold out through preorders priced at US \$549 (the retail price will be \$749).

Last April, I leapt at a chance to try the Halo myself. I've been following the recent emergence of brain-stimulation technologies, watching with fascination as people electrify their heads in medical and recreational pursuits. At the high end, the trend includes surgically implanted deep-brain stimulators for such applications as helping Parkinson's disease patients move normally. At the low end, an assortment of noninvasive systems that send current through the scalp are easy and cheap enough for DIYers to try at home. We can all be brain hackers now.

Ready to give it a try? If you want to build your own rig, all you need is a 9-volt battery, some simple circuitry, and a couple of sponge electrodes to strap to your scalp. Over the past few years,

enthusiastic self-experimenters (<http://spectrum.ieee.org/geek-life/reviews/the-latest-diy-craze-brain-hacking>) have taken to Reddit (<https://www.reddit.com/r/tDCS/>) and message boards to trade tips on the most basic technique for brain stimulation, called transcranial direct-current stimulation (tDCS). People also post poignant questions on the forums, asking for advice on using homemade tDCS systems to treat disorders such as depression, anxiety, and chronic pain.

Now entrepreneurs are bringing out commercial devices, hoping to launch an entirely new category of wearables. These startups don't make overt medical claims, so they've avoided the scrutiny of government regulators thus far. (If you're merely curious about research studies that use tDCS to treat depression, well, they're happy to provide information, including detailed charts of electrode placements.) But the dozen or so companies in this nascent market are bolder in declaring how their products make healthy people even better. If you believe the websites, these devices improve memory, focus, creativity, and learning. Do you want to be more socially adept? Better at math? Free of your cigarette addiction? You get the idea.

"There are tDCS devices that claim to basically make you a superhero," says Hannah Maslen ([http://www.neuroethics.ox.ac.uk/our\\_members/hannah\\_maslen](http://www.neuroethics.ox.ac.uk/our_members/hannah_maslen)), a bioethicist who studies brain-intervention technologies at the University of Oxford's Centre for Neuroethics. "Some of the claims they make are not even theoretically plausible from a neuroscience point of view."

While tDCS has been studied extensively in carefully controlled lab conditions, it's tough to translate sensitive neurotechnology into mass-produced consumer gadgets that work without fail for every user, every time. One of the few independent studies of a commercial brain-stimulation gadget looked at the first product from the London-based startup Foc.us (<http://www.foc.us/>). According to the company's marketing, the device improved attention and memory to make users better at video games. Yet researchers found exactly the opposite effect (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4751189/>): When subjects used the headset while performing a memory task, they actually did worse.

Halo Neuroscience, though, appears more legit. Its cofounders, Daniel Chao and Brett Wingeier, previously worked for NeuroPace (<http://www.neuropace.com/>), a medical-device company that developed a breakthrough brain implant for epilepsy patients. In conversation, the cofounders seem borderline obsessed with their double-blind, sham-controlled research studies. And they don't claim their device can do everything. Instead they make only one claim, although it's a doozy: Halo Sport will help athletes reach new heights of performance.

On my way to the gym for my Halo tryout, my mind buzzes with questions. Is this thing for real? And if it does improve athletic performance, am I witnessing the dawn of brain doping?

Before my first session with the device I get a science briefing from Chao and Wingeier. Befitting a tech startup, Halo's stylish and airy offices in downtown San Francisco feature stand-up desks in an open layout, a kitchen stocked with pistachios, and cleverly named conference rooms. "Frontal Cortex" is up front near reception; we convened in "Hippocampus," tucked away toward the back.

Chao, with both a master's in neuroscience and a medical degree from Stanford University, covers biology, while Wingeier, who has a Ph.D. in biomedical engineering, talks tech. The two left their jobs at NeuroPace in 2013 after U.S. regulators approved the company's epilepsy implant ([http://www.neuropace.com/wp-content/uploads/2015/11/NeuroPace\\_Press\\_Release\\_PMA\\_Approval\\_2013-11-14.pdf](http://www.neuropace.com/wp-content/uploads/2015/11/NeuroPace_Press_Release_PMA_Approval_2013-11-14.pdf)) [pdf]; with that milestone met, they were ready to start a new venture. They didn't have a precise plan for a product, but they expected it would be another medical device. "We never would have predicted that we'd become a sports-science company," Chao says.

Here's what they knew for sure: They wanted to build a company based on tDCS. In this brain-hacking technique, anode and cathode electrodes are placed at certain locations on the scalp to channel current through targeted brain regions. Interest in the method has boomed since 2000, when

researchers published the first important studies demonstrating tDCS's effects on humans (<http://www.ncbi.nlm.nih.gov/pubmed/10990547>). Last year, more than 600 tDCS studies came out. The range of research is staggering, because there are as many potential applications as there are brain regions to target. Investigators are testing tDCS as a treatment for disorders such as addiction, ADHD, Alzheimer's, aphasia, and autism—and those are just the ones that start with “A.” In another line of inquiry, scientists are trying to figure out if tDCS can influence mental processes such as creativity, morality, learning, and memory.

But while eager scientists are exploring all the things that tDCS might be able to do, a cadre of skeptics argue that many promising results won't pan out. One prominent voice belongs to Vincent Walsh (<http://www.ucl.ac.uk/icn/people/applied-cognitive-neuroscience>), a professor of cognitive neuroscience at University College London. He argues that tDCS studies have found only minor effects that he calls “overhyped,” notes that many results have not been replicated, and worries about positive reporting bias: “I don't think people are reporting all the experiments that don't work,” he says.

Within this complicated context, the Halo guys took a cautious approach. “In the first year of our operation, we did something very different from other startups: We didn't think about product,” Chao says. Instead, they made a spreadsheet listing all of the possible brain targets for tDCS and started experimenting, using a crude prototype to run tests on more than 1,500 volunteers. They were looking for stimulation procedures that produced measurable and reliable results.

The standout data came from experiments involving the motor cortex, the brain region that controls voluntary movements. So Chao and Wingeier asked themselves who would be interested in a product that could augment activity in that brain region, and the answer was obvious: athletes. They started working on the Halo, though Chao says he worried that sports teams wouldn't be ready to embrace brain stimulation: “That's one of the things that kept me up at night: What would my first meeting be like with the general manager of a baseball team? Would I get laughed out of the office?”



Photo: Gabriela Hasbun.

**High-tech Headphones:** Athletes can play their workout music through the Halo Sport while the discreet neurotechnology tucked inside pumps up their brains. **Easy Access:** The Halo Sport's spongy electrodes are attached to the band between its earphones. In that position they naturally stimulate the user's motor cortex, a strip of brain tissue that arcs from ear to ear.

The company's decision to target the motor cortex was scientifically sound, says leading tDCS expert Marom Bikson (<http://bme.cuny.cuny.edu/people/faculty/mbikson>), a professor of biomedical engineering at the City College of New York. “It's pretty unequivocal that when you apply tDCS in a

certain way, you change the excitability of the motor cortex,” he says, citing papers that showed clear effects on movement, using metrics such as the speed of finger tapping. He quickly adds, however, that there’s a big difference between finger dexterity and athletic performance. Scientists haven’t looked at outcomes like a sprinter’s speed or a baseball player’s slugging percentage, Bikson says. Companies such as Halo “are often more aggressive in their claims than scientists would be.”

While Bikson reserves judgment on the Halo, the skeptical Walsh is willing to make a prediction. “The hype will make some short-term sales,” he says. “And then a lot of sports institutes will have unused machines in their storerooms.”

Though experts disagree about tDCS’s effectiveness and its exact mechanism, the underlying science isn’t under dispute. The brain is an electric organ, and its 86 billion neurons communicate via pulses of electricity. When a voltage change causes one neuron to “fire,” it releases chemicals that trigger voltage changes in connected neurons. The brain’s every operation, from automatic functions like maintaining a heartbeat to cognitive processes such as making sense of these words you’re reading, can be understood as a flickering pattern of electrical activity, with neurons firing along specific pathways.

When a tDCS gadget sends a trickle of current through someone’s scalp, it makes neurons in the stimulated brain regions more likely to fire. And each time the brain activates a neural pathway, it strengthens the connections between those cells. That’s why repeated stimulation can have long-lasting impact, and also why practicing a new skill improves performance: As French students recite verb conjugations or golfers work on their swings, they’re reinforcing the associated neural pathways.

Halo Sport goes to work on neurons in the motor cortex that send commands through peripheral nerves to the muscles. But athletes can’t just slap on their Halos while sitting on the couch and expect to get better at basketball. Instead, they must pair stimulation with training, wearing the Halo while shooting free throws, for example, to reinforce the proper pathways. “You still have to do the work,” Chao says. The same principle makes the Halo a useful strength-training tool, he argues, because “weight training is as much of a skill as a fine motor task.” An athlete who wears the gear while hoisting barbells will train the motor cortex to better activate the muscle fibers, providing a little more payoff from each rep.

Is sending a trickle of current through the brain safe? As I discovered when describing my reporting project to friends, it sure alarms most people. Some neuroscientists call this reaction the *One Flew Over the Cuckoo’s Nest* effect, named after the book ([https://en.wikipedia.org/wiki/One\\_Flew\\_Over\\_the\\_Cuckoo%27s\\_Nest\\_\(novel\)](https://en.wikipedia.org/wiki/One_Flew_Over_the_Cuckoo%27s_Nest_(novel))) and movie ([https://en.wikipedia.org/wiki/One\\_Flew\\_Over\\_the\\_Cuckoo%27s\\_Nest\\_\(film\)](https://en.wikipedia.org/wiki/One_Flew_Over_the_Cuckoo%27s_Nest_(film))) featuring a psychiatric nurse who wielded electroshock therapy like a weapon, turning rebellious spirits into complacent zombies.

But leaving aside the fact that electroconvulsive therapy (<http://www.mayoclinic.org/tests-procedures/electroconvulsive-therapy/basics/definition/prc-20014161>) (to give the treatment its proper name) is widely regarded as a valid way to shake deeply depressed people out of despondency, there’s the matter of magnitude to consider. In typical ECT, a current of 800 or 900 milliamperes flows through the patient’s head, causing a seizure that serves as a neurological reset. Halo Sport’s current tops out at 2 mA. It’s more like being hooked up to a potato battery than an electroshock machine.

I’m eager to see what a couple of milliamps will do for my motor cortex and biceps when I march through the doors of the Menlo Park training facility on that April morning. As a Guns N’ Roses song echoes through the cavernous space and free weights clang onto the concrete floor, I chat with the Halo employee who brought my gear.

The Halo Sport is meant to be as intuitive and easy to use as an Apple product, with just one button on the headset and all functions controlled by a smartphone app. I can change the stimulation level and duration (20 minutes is standard) and choose between stimulation settings that focus on the upper or lower body. The Halo’s spongy electrode pads are tucked into the band between the



earphones; when I settle the device on my head, the electrodes naturally rest over my motor cortex, a strip of brain tissue that arcs from ear to ear. I press the band more firmly to my scalp and check the Halo app. It stubbornly shows a “poor connection” error.

The Halo can’t start until the app detects a steady connection between the electrode pads and my scalp, and that just isn’t happening. When the Halo rep tries it on himself, the app screen immediately lights up green for go. But on me, no amount of wiggling or pressing or repositioning the headphones does the trick. It isn’t my hair, says the dismayed rep; he’s seen the Halo work fine on athletes with Afros, cornrows, and dreadlocks.

It turns out the gear isn’t defective—my head is. When we troubleshoot later at Halo headquarters, Wingeier tells me they’ve tested the device in more than 3,000 sessions, and I’m only the second person who can’t get it working. Wingeier’s phone app displays a diagnostic readout showing my electrical resistance to be off the chart. The Halo is programmed to abort if it encounters resistance above 12,000 ohms, and mine clocks in at 45,000. “Every time something like this happens, we learn a little bit,” Wingeier says wearily.

As he reprograms the device to override the shutoff, Wingeier tactfully refrains from making any jokes about my thick skull. With the settings changed, my Halo works fine during a four-day tryout with intriguing results [see chart in “Buffed-Up Biceps”]. When the device powers up there’s a slight tingle in the skin under the electrode pads, but it fades to nothing after a few seconds. Then I simply feel like I’m wearing good audio headphones: To help athletes forget the technology and focus on the training, the Halo even connects to a phone or iPod to play music.

I may be a highly resistant anomaly, yet my experience points to a difficulty for the company. Can it build a mass-market neuroscience device, I ask the cofounders, that works on all sorts of brains, which are as unique as snowflakes in their anatomical details and workings?

According to Wingeier, the company’s tests have shown that its product “works great for the majority of the people the majority of the time.” Chao also compares their first offering to the Model T, the first mass-produced automobile. As they figure out what individual consumers want and need, they can start making “sports cars and SUVs and compact cars and station wagons,” Chao says. And maybe even some with color schemes besides basic black.

The company validated its standard protocol in several double-blind, sham-controlled trials, which it published as white papers (<https://www.haloneuro.com/science>). One study showed that the Halo Sport’s stimulation enabled users to exert more force in a finger-pinching task (<https://halo-website-static-assets.s3.amazonaws.com/whitepapers/mvc.pdf>) [pdf], while another demonstrated its positive effect on a fine-motor-skill task (<https://halo-website-static-assets.s3.amazonaws.com/whitepapers/cct.pdf>) [pdf] requiring subjects to strike different keys on a keyboard. Now the team is writing up a study that examined muscle output via a bicep-curl machine, a setup that more closely resembles real-world athletic training. Going forward, Chao says the company will publish its findings in peer-reviewed journals.

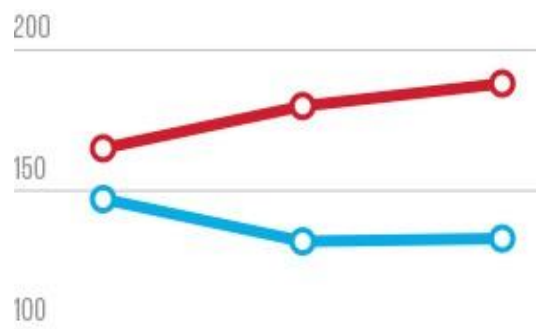
These studies measured each test subject’s performance during a single stimulation session, but the Halo Sport is really meant to be part of a long-term training regimen. People who have plenty of room to improve may get immediate results, but serious jocks will likely need a week or two before they notice a difference. And the very best athletes, those who dream of championship rings and gold medals, may see the smallest gains—yet be the most satisfied customers.

Take, for example, the skiers and snowboarders already training for the 2018 Winter Olympics. Troy Taylor (<http://ussa.org/news/ussa-names-new-high-performance-director>), high-performance director for the U.S. team (<http://ussa.org/believeinus>), is responsible for finding equipment that will give them an edge. He says he gets pitched upwards of 500 products each year, including all manner of dubious supplements and wearable gadgets. But when he heard about the Halo, it stuck out as a possible solution to a problem his mountain-bound athletes face.

When soccer or basketball players train, Taylor says, they might spend 70 or 80 percent of their time practicing their sport. “But in skiing and snowboarding, our athletes spend maybe 5 to 10 percent of their time actually sliding over snow,” he says. Much of the rest of the time they’re cooling their heels on chairlifts. A technology that could speed up an athlete’s ability to learn, maximizing the impact of those precious downhill runs, interested him greatly.

Taylor set out to determine whether the Halo worked as advertised and could be a useful training tool. So in late 2015, he began his own research trial with a group of ski jumpers in the team gym. While receiving either real or sham stimulation, the athletes practiced launching themselves upward from a slippery board that rested on rollers. “I can barely stand on this thing,” Taylor says. “But an elite athlete can stand on it and then jump.” A force plate beneath the board measured the power of the skiers’ jumps as they learned this skill over the course of three weeks. The results: The sham group improved by 18 percent, while the real stimulation group improved by 31 percent.

The jumpers all had instant feedback on each attempt, helping them continually fine-tune how they controlled their muscles. With the Halo’s neural stimulation reinforcing those control patterns, Taylor says, the skiers sped up their normal learning process. He was sold. The key to making today’s extraordinary athletes even better doesn’t lie in upgrading their physiques, Taylor says, but rather in upgrading their brains. “We’re excited, and we think it may provide us with a competitive advantage leading into the 2018 Olympics,” he says.



Gif: Gabriela Hasbun.

**Buffed-up Biceps:** When the author used a bicep-curl machine without neural stimulation [in blue], her force output declined due to normal fatigue over three sets of bicep curls. Four days later, with stimulation [in red], her force output increased, suggesting that the Halo Sport was boosting her performance. Measurements are in newtons.

But such initial successes raise a question: Does brain hacking constitute brain doping? Taylor certainly doesn’t think so. He says any performance booster that doesn’t endanger the athlete’s health

and hasn't been banned by the authorities is fair game. "It's my job to push the boundaries," he declares.

The World Anti-Doping Agency (<https://www.wada-ama.org/>) (WADA) compiles the list of performance-enhancing substances and treatments forbidden by the International Olympic Committee. Olivier Rabin (<https://www.wada-ama.org/en/dr-olivier-rabins-biography>), WADA's science director, says his team is "very actively monitoring" brain-stimulation technologies, and recently discussed whether tDCS and similar techniques warranted inclusion on the prohibited list (<https://www.wada-ama.org/en/what-we-do/prohibited-list>). Their verdict: It's not yet time to make that decision. "At the moment, our experts consider that there is a lack of objective information about these technologies," he says.

First, Rabin says, he'll need to see scientific proof that tDCS does enhance athletic performance. And he's not holding his breath. In his 14 years on the job, he's seen plenty of hyped technologies that don't pan out, he says. But if tDCS's benefits are verified, WADA will judge the technology on two other criteria: whether it risks the health of the athlete, and whether it violates "the spirit of sport." A positive finding in either category is grounds for a ban.

Both of these criteria pose knotty problems. Thousands of clinical trials have proven tDCS safe in the short term—the worst side effects have been skin irritation under the electrodes and the occasional headache. But the technology is so new that long-term safety studies simply haven't been done yet. As for the other criterion, good luck getting a clear definition of "the spirit of sport." WADA's official World Anti-Doping Code (<https://www.wada-ama.org/en/what-we-do/the-code>) defines the term with a long list of principles meant to sum up "the essence of Olympism, the pursuit of human excellence through the dedicated perfection of each person's natural talents." If, in the end, the authorities decide tDCS should be banned, they'll still have a conundrum: There's no way to test for it.

While the authorities dither, Halo will do its best to slip into the mainstream. And athletes are just the first customers targeted by this ambitious company. In South Carolina, a neurologist is currently testing the Halo with stroke patients to see if stimulating the motor cortex speeds up rehab. Chao envisions a whole range of Halo products offering consumers different kinds of mental boosts. "What if you want to learn Chinese and we stimulate the language center?" he says. "What if we stimulate the memory center and pair that with brain-training games?"

If sports heroes embrace a technology that makes them slightly better versions of themselves, people watching from the stands may well become eager to optimize themselves too. In this new society of swifter, stronger, smarter human beings, I'll be the old-fashioned person wandering around with a weirdly thick head.

## **Brain-Zapping Gadgets Need Regulation, Say Scientists and (Some) Manufacturers**

**Posted 31 Aug 2016**

**IEEE Spectrum**

**By Eliza Strickland**

Just a few years ago, the idea of electrically stimulating your brain in the comfort of your own home would have sounded pretty weird, and probably like a bad idea. But the practice of brain-zapping—in particular, an easy-to-pull-off technique called transcranial direct current stimulation (tDCS ([http://www.hopkinsmedicine.org/psychiatry/specialty\\_areas/brain\\_stimulation/tDCS.html](http://www.hopkinsmedicine.org/psychiatry/specialty_areas/brain_stimulation/tDCS.html))) — has quickly advanced from labs to living rooms. DIYers are building their own devices

(<http://spectrum.ieee.org/geek-life/reviews/the-latest-diy-craze-brain-hacking>) and trading tips online, while startups are bringing out consumer products (<http://spectrum.ieee.org/biomedical/bionics/olympic-athletes-are-electrifying-their-brains-and-you-can-too>).

With that as the backdrop, a group of neuroscientists and manufacturers met in New York City on Sunday (<https://neuromodec.com/event/non-invasive-neuromodulation-technology-and-regulation-meeting/>) 28 August to discuss potential regulations for brain stimulation devices sold directly to consumers. “Neuromodulation is already here—it’s on Amazon, it’s in the coverage of the Olympics, it’s everywhere,” said conference organizer Marom Bikson (<http://bme.ccny.cuny.edu/people/faculty/mbikson>), a professor at the City College of New York. “But there isn’t a cohesive message from scientists or industry about regulations. As a community, we’re behind.”

The group agreed on Sunday to suggest guidelines to the U.S. Food and Drug Administration (FDA), which sets rules for medical devices. The FDA has been discussing this possibility of regulating neurotech for at least two years, said James Giordano (<https://clinicalbioethics.georgetown.edu/JGiordano>), chief of the neuroethics studies program and a professor of neurology at Georgetown University in Washington, D.C. “I’ve been part of those discussions,” Giordano said.

While tDCS isn’t the only type of noninvasive brain stimulation, it’s the simplest: The user just presses a couple of electrodes to the scalp to send a tiny amount of current through a specific region of the brain. The effects depend most obviously on where the electrodes are placed, but also on factors such as current amplitude, stimulation duration, and existing conditions in the user’s brain.

Neuroscientists are testing tDCS’s effects on every neural and psychological disorder you can imagine, and are also investigating its effects on cognition, emotion, and behavior. It’s fair to say it’s a hot topic of research: The chart at right, from the PubMed database, shows the number of papers published on tDCS (<http://www.ncbi.nlm.nih.gov/pubmed/?term=tDCS>) over the years. In 1989, there were two such papers published; last year there were 608.

In Europe, tDCS was recently approved for depression and chronic pain. While the FDA has yet to follow suit and approve its use in the United States for any medical conditions, such a move seems inevitable. And since tDCS can be easily administered by a portable device, clinicians are already thinking about how at-home medical use could safely be permitted. (<http://www.businesswire.com/news/home/20160114006356/en/Soterix-Medical-Launches-PainX-tDCS-Treatment-EU>).

At the meeting on Sunday, several researchers explained how at-home clinical treatment could work: Physicians could control “dosage” by providing a unique keycode for each stimulation session that allows activation of the device, and could use Skype to supervise patients as they familiarized themselves with the gear. Researchers also stressed the need for standardized devices that position the electrodes properly on the user’s head.

But consumers using products they buy on Amazon need a different set of protections, Giordano told *IEEE Spectrum* in an interview.

Some of the first products that came on the market made inaccurate claims about their benefits, Giordano said. The manufacturers made statements based on scientific studies that used research-grade tDCS equipment under carefully controlled conditions. But the companies hadn’t carried out those same studies using their own products.

“That’s like saying, ‘A Maserati can go 200 miles per hour. The Maserati is a car, and I also make a car, and therefore my car goes 200 miles per hour,’” Giordano said. “Oh, and also, I’m not using my car on a racetrack, and I don’t have an experienced race car driver behind the wheel.” As a first step toward a responsible marketplace, Giordano said, manufacturers must be required to clearly define and support their claims, and to carefully communicate what their devices can and cannot do.

The group’s guidelines will also recommend that people with neural or psychiatric conditions consult their physicians before using any brain stimulating gadget. That category includes people with

conditions like depression, anxiety, and addiction, who are already turning to DIY treatments using homemade or commercially available tDCS rigs.

Finally, they'll recommend that neuromodulation devices not be used by children unless a physician explicitly recommends such use. There are too many unknowns regarding its effects on the developing brain, Giordano says.

Setting such regulations won't stop people from doing whatever they want with devices. But then it becomes a matter of "buyer beware," says Giordano. "We'll tell you how to use something properly, and if you chose to deviate from that, that's your choice," he says. "Sears can sell a chain saw with perfectly good intentions that it only be used to cut wood, but some idiot is going to juggle it."

The group that met on Sunday included representatives of a few companies that either sell a tDCS product now or intend to launch one soon. The speakers made the case that all manufacturers should get on board with these proposed regulations, because setting clear rules for their products' use can protect them from lawsuits. But such widespread buy-in may be wishful thinking.

Giordano named two of the companies represented on Sunday as exemplars of what the field should aspire to: Halo (<https://www.haloneuro.com/>), whose brain-stimulating gadget for athletes (<http://staging.spectrum.ieee.org/biomedical/bionics/olympic-athletes-are-electrifying-their-brains-and-you-can-too>) will soon go on sale, and Soterix (<http://soterixmedical.com/>), which sells tDCS units for medical and research use only. These companies, Giordano said, are doing their own research to back up their claims. "Those two companies are doing it right," Giordano said. "The implication is that other companies are not doing it as well."

Some companies claim not only that their devices treat disorders like depression, anxiety, addiction, and chronic pain, they also boast of improving cognition, memory, and social skills. Many DIYers seem most interested in these enhancement possibilities of tDCS.

That experimentation makes scientists nervous. In a recent open letter to DIY users (<http://onlinelibrary.wiley.com/doi/10.1002/ana.24689/full>), 43 leading academics pleaded with users to consider that neuroscientists are still trying to answer basic questions about how tDCS works, and that many safety issues remain unresolved. That letter noted that stimulation is not as targeted as many people assume; enhancing one cognitive function may come at the cost of others, and "whatever brain changes occur may be long-lasting—for better or worse."

## **First-Generation Augmented Reality Games Are Harbingers of Better Mind-Expanding Tools**

**Posted 24 Aug 2016 | 19:00 GMT**

**IEEE Spectrum**

**By G. Pascal Zachary**

The Pokémon Go craze highlights how digital devices grab hold of our minds—and don't let go. Images of well-dressed people hunched over smartphones, staggering dangerously along city streets, riveted by the appearance onscreen of imaginary characters set in their visible terrain, epitomize what's gone wrong with our computer-mediated world.

Think again.

Sneering at Pokémon Go is misguided. The new gaming experience, while providing only a pale version of augmented reality, suggests that in the future, digital devices will expand our minds and improve our decision-making. In a competitive world, tools that make us smarter—and aren't physically invasive or addictive—will receive a warm welcome, especially because they seem safer than either genetic engineering of our brains or regular ingestion of pharmaceuticals.

Remember the drug “soma” of Aldous Huxley’s *Brave New World*? Biochemical compounds are physically addictive, while switching off your smartphone never causes nausea.

Government regulations on drugs mean years, if not decades, of safety studies. Legal barriers to mind-expanding drugs shift only slowly. Meanwhile, digital pathways to cognitive enhancement (<http://www.nickbostrom.com/cognitive.pdf>) [pdf] (CE) such as the brain-training site Lumosity (<https://www.lumosity.com/>) and behavior-modification games such as SuperBetter (<https://www.superbetter.com/>) quickly gain market acceptance.

Cynics can dismiss Pokémon Go as a waste of time, but the pursuit of computer-aided intelligence (<http://neurorehab.bancroft.org/wp-content/uploads/2015/07/Exercise-and-CognitionBNR-webinar-2015FINALv2-1.pdf>) is not. The new Pokémon exploits the sweet spot in enhancement technologies: mobility. We think best when we are in motion. Walking, running, even yoga are associated with improved cognition (<http://neurorehab.bancroft.org/wp-content/uploads/2015/07/Exercise-and-CognitionBNR-webinar-2015FINALv2-1.pdf>) [pdf]. Devices that move with us-and in real time elevate the quality of our decisions, and our grasp of the world around us-suit us well.

Game simulators, however useful, strap down players, cocooning them in an unnatural, digital pod. *Minecraft*, for instance, helps people learn by rehearsing actions, but it constrains players physically and mentally. In the real world, humans make hard decisions on the fly, creatively responding to ever-shifting environments and social settings. They must analyze and improvise in motion.

The trick is to provide relevant information almost as fast as the human mind probes, searches, and settles on the “right” answers.

Mobile CE works best on the premise that your mind should be freed up to tackle the hardest problems, leaving routine cognitive tasks to computers. Microsoft’s newest version of Word, for instance, promises to find the relevant quotes, citable sources, and images—without you leaving the document. The less time you spend hunting, the more time you have to think creatively. Similarly, Pandora automates the process of choosing music. Evernote helps you recall your to-do list. Google’s timely facts strengthen your arguments. These digital tools help you finish your thoughts, so you become better prepared and more confident in your decisions.

Individuals may differ over digital paths to CE. But if an entire civilization embraces enhancement, the world advances. The visionary H.G. Wells drew on this hope when, in 1937, he envisioned a networked encyclopedia, stored on microfilm that would act as a “mental clearing house for the mind.”

Wells’s “world brain” was stationary: tethered intelligence. Even he couldn’t imagine tetherless sources of knowledge that easily and instantly support effective decisions. Today’s digital tools, from Google Search to smartphones and sensor data, increasingly provide intelligence on the move.

And because we humans are fundamentally restless minds in motion, we are on the verge of a great leap forward in the quality of our purposeful thought, both individual and collective.

## **Don't Like Their Faces? Train Your Brain to Feel More Positive**

**Posted 16 Sep 2016 | 17:00 GMT**

**IEEE Spectrum**

**By Emily Waltz**

Like it or not, we often have positive or negative feelings about a total stranger based solely on the looks of his or her face. A person’s features, expressions, gender, and skin color can generate emotions that we can’t control in that moment. Because, let’s face it: We’re biased about faces, and that can affect everything from getting a job to getting a date.

Last week, researchers described, in the journal *PLOS Biology* (<http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1002546>), a brain training system that can alter emotions evoked by the sight of someone's face. With just a few days of training, study volunteers felt more positively or negatively about a photo of a stranger. The change in feeling was slight but statistically significant, and could become more pronounced with further training, says Mitsuo Kawato (<http://www.cns.atr.jp/~kawato/>), a computational neuroscientist at the Advanced Telecommunications Research Institute International in Kyoto, Japan. Kawato is one of the paper's coauthors.

The study brought Kawato and his colleagues one step closer to their end goal: helping people with post-traumatic stress disorder (PTSD), anxiety, depression, phobia, and other mental disorders by manipulating their feelings about past events. A soldier who saw awful things during combat, or a person who was abused as a child could theoretically retrain their brain to feel more neutral about those experiences. "If we can manipulate brain memory unconsciously by this technique, it could be very beneficial for fear extinction," says Kawato.

The experiment involved functional magnetic resonance imaging (fMRI), a software decoding program, and tricking 24 volunteers. Kawato's team showed the participants 400 photos of faces, and asked them to rate their sentiments about each one on a scale of 1 to 10—with 1 representing strong dislike, 5 being neutral, and 10 for strong positive feelings.

Meanwhile, an fMRI machine recorded the participants' neuronal activity in a region of the brain called the cingulate cortex. (fMRI measures brain activity by detecting changes in blood flow, which correlates with neuronal activity.) The software, based on a machine learning algorithm, then decoded the brain activity of each participant, noting the patterns associated with positive and negative emotions.

The researchers later called the participants back to the lab, put them in the fMRI scanner and showed them a subset of faces that they had rated as neutral. After each face, researchers showed the volunteers an image of a green disc. And here's where the trick—and the training—happens. The researchers told the participants that if they could somehow make the image of the green disc bigger with their minds, they would receive a monetary reward.

Volunteers were given no further instructions and did not know the purpose of the study.

By this stage of the experiment, the volunteers had been divided into three groups: some in a "positive" group, some in a "negative" group, and others in a control group.

The only way the green disc would get larger is if the volunteer managed to generate the same brain activity patterns he or she used when feeling positive or negative emotions about a face. Volunteers in the positive group had to generate the patterns they generated for faces they rated as positive, and vice versa for the negative group.

The neurofeedback system worked. When the volunteers later rated the neutral faces again, the positive group rated the formerly neutral faces as slightly more positive, and the negative group rated them as slightly more negative.

The control group showed no change in feelings.

The fact that the brain activity monitored over the course of the experiment was going on in the cingulate cortex helped land the group's work a spot in *PLOS Biology*. Previous research suggested that brain activity associated with positive and negative reactions to faces comes from multiple brain regions. Kawato's group says it is the first to show that focusing on just the cingulate cortex is sufficient for manipulating both positive and negative facial preferences.

That region of the brain is already known to play an important role in affective disorders such as depression, PTSD, and phobias, says Kawato. Being able to manipulate that part of the brain in order to affect facial preference (which is an emotional condition), bodes well for the group's chances for targeting debilitating mental disorders.

Earlier this year, the team used the same fMRI and decoding software technique, which they call DecNef, to brain train another group of volunteers. That group of subjects was trained to associate a color with a pattern. The experiment worked so well that, eventually, the volunteers would see a color cued by a pattern, even though the color was not there. Kawato's team first demonstrated (<http://science.sciencemag.org/content/334/6061/1413>) the technology in 2011 in *Science*.

Kawato is aware that his technique sounds a lot like brainwashing. Indeed, one of the reasons his group published the paper was to notify the public and give people a chance to discuss the ethical implications of the technology, he says. In this particular experiment, because subjects had voluntarily lied in an MRI scanner for 1.5 hours at a time, "It's difficult to imagine this technique being used for brainwashing against a subject's will," says Kawato.

As scientists get better at brain training, the public will have to decide what kind of emotion and memory manipulation is acceptable. Altering ourselves to like people we shouldn't like can be dangerous. But of course, in a way, we already have that technology. It's called alcohol. Just ask anyone wearing one of these (<http://www.trippytees.com/drink-til-he-s-cute-t-shirt.html?mobile=0>).

## Injectable Nanowires Monitor Mouse Brains for Months

Posted 29 Aug 2016 | 15:32 GMT

IEEE Spectrum

By Neil Savage

Want to understand what happens to the brain as it ages, or figure out how people learn to recognize faces? Neurologists asking such questions, or struggling to deal with brain degeneration caused by Parkinson's and Alzheimer's, might get some insight from detailed observations of the brain's circuitry over time. But so far, such information has been hard to come by.

Now researchers at Harvard have shown that they can track brain activity, at the level of individual neurons, for months at a time, using a tiny electronic mesh (<http://spectrum.ieee.org/biomedical/devices/nanowire-mesh-links-cells-and-electronics>) that can be injected directly (<http://spectrum.ieee.org/tech-talk/biomedical/bionics/injectable-electronics-give-neurology-a-shot-to-the-brain>) into the brain. A group led by Charles Lieber (<http://cml.harvard.edu/people/charles-m-lieber>), a chemistry professor at Harvard, reports in this week's *Nature Methods* (<http://nature.com/articles/doi:10.1038/nmeth.3969>) that they were able to record the neural activity of mice over eight months, long enough to see how the animals' brains changed as they entered the mouse version of middle age.

"This really brings us the ability to pick apart the circuits that are involved in fundamental information processing with the brain as they develop," Lieber says.

The team builds the mesh out of very thin silicon wires coated in a polymer, with crossing lines made entirely of polymer; together they form simple field-effect transistors (<http://spectrum.ieee.org/semiconductors/processors/harvard-team-makes-programmable-logic-from-nanowires>). The mesh naturally curls up when it's put in a liquid, and can be drawn into a syringe and injected. Once in the brain, the mesh uncurls and sits on top of the neurons.

Implantable electrodes already exist, of course; doctors place them in the brains of some Parkinson's patients to provide deep brain stimulation, which can help control tremors. But such devices are large and stiff and tend to irritate the brain tissue. The brain responds by engulfing them in a layer of cells, which insulates them and makes receiving or transmitting electrical signals more difficult.



By contrast, Lieber's meshes are soft and flexible, and the transistors (<http://spectrum.ieee.org/computing/hardware/rudimentary-computer-built-from-nanowires>) they form are smaller than the brain cells; they don't provoke an immune response and they stay where they're put. Where other implants lose their usefulness in days or weeks, the Harvard team's meshes kept functioning for the entire length of the eight-month experiment.

The researchers also included some electrodes that could provide electrical stimulation to the brain. Lieber's hope is that, if scientists can identify what goes wrong in the brain's circuitry—leading to, say, Parkinson's—at an early stage, they could use some sort of stimulation to alter or at least slow the process.

Statistical analysis of the signals they recorded showed that they were picking up activity from individual neurons, and that they could follow the same neurons over time. This ability could provide neurologists with a detailed map of what's going on in, say, the visual cortex during learning, or let them watch the process by which memories are formed and how that process degrades with age.

Lieber would also like to use the devices in other parts (<http://spectrum.ieee.org/nanoclast/medical/devices/nanowires-offer-realtime-monitoring-and-control-of-heart-tissue>) of the nervous system. A mesh over the retina might yield some information about what's happening in the eye and how that ties into what the neurons are doing. A set of electrodes in the spinal cord might provide new information, or even a new form of therapy, in cases of traumatic injury.

## **From Passwords to Passtoughts: Logging in to Your Devices with Your Mind**

**IEEE Spectrum**

**By Emily Waltz**

**Posted 31 Aug 2016 | 19:00 GMT**

A password, a fingerprint (<http://spectrum.ieee.org/tech-talk/medical/imaging/print-3-d-fingerprints-for-better-biometrics>), or an iris scan (<http://spectrum.ieee.org/the-human-os/medical/imaging/biometric-researcher-asks-is-that-eyeball-alive-or-dead>)—these are ways to verify that we are who we say we are, allowing us to log in to our devices or enter a high security area. But if we are to move beyond touch screens and keyboards, our methods of authentication will have to change too. That has pushed engineers to find new ways to verify our identities, and to do it directly from the source: the brain.

When we perform mental tasks like picturing a shape or singing a song in our heads, our brains generate unique neuronal electrical signals. A billion people could mentally hum the same song and no two brain-wave patterns generated by that task would be alike.

An electroencephalograph (<http://www.mayoclinic.org/tests-procedures/eeg/basics/definition/prc-20014093>) (EEG) would read those brain waves using noninvasive electrodes that record the signals. The unique patterns can be used like a password or biometric identification. In fact, researchers have taken to calling them “passtoughts.” And really, what more foolproof way to prove that someone is who he says he is than to hack his thoughts?

Engineers have been tinkering with the idea for about a decade now, and some have developed devices that they say are 100 percent accurate (<http://spectrum.ieee.org/medical/devices/brainprint-biometric-id-hits-100-accuracy>). But those efforts have involved placing electrodes smack dab on the forehead or conspicuously across the scalp.

Researchers have also developed in-ear EEG sensors that read brain waves for the purposes of controlling a computer or monitoring sleep (<http://spectrum.ieee.org/the-human-os/biomedical/devices/in-ear-eeg-makes-unobtrusive-brain-hacking-gadgets-a-real-possibility>). But until recently, those groups hadn't tried to optimize in-ear EEGs for use as passthrough readers.

John Chuang (<http://www.ischool.berkeley.edu/people/faculty/johnchuang>) and his colleagues at the University of California at Berkeley married the two avenues of work by developing a passthrough reader integrated into an everyday set of earbuds. Chuang presented the idea earlier this month at IEEE's Engineering in Medicine and Biology Society Conference (<http://embs.org/2016/>) in Orlando, Fla.

Chuang's group built the device using a consumer-grade single-electrode EEG headset called the NeuroSky Mindwave (<http://store.neurosky.com/pages/mindwave>), which sells for about US \$100 online. The electrode is intended to be placed on the forehead. Chuang's group simply took it out of its casing and fitted it for the ear. They then ran a small study to see how reliably it could read brain waves.

The rudimentary device was surprisingly accurate. Twelve volunteers each performed two sets of five mental tasks; the earpiece correctly confirmed their identities 72 to 80 percent of the time. These results suggest that with further development, a single electrode integrated into a set of earbuds could be used as a method of authentication. No hands required.

Chuang's team had previously done authentication testing with the NeuroSky electrode placed where its designers intended—on the forehead—and found that it was accurate more than 99 percent of the time ([http://link.springer.com/chapter/10.1007%2F978-3-642-41320-9\\_1](http://link.springer.com/chapter/10.1007%2F978-3-642-41320-9_1)). So they knew it worked. Getting it to work in the ear may be a matter of finding the optimal location, or fitting it appropriately in the ear, says Chuang.

That's the next logical step to making a practical, real-world device. "Clearly a lot more work needs to be done for this to be effective and useful in the real world," says Chuang. "But at least we know this is an area that we can continue to investigate."

Another challenge is making a device that is accurate even when the wearer's physiological and mental states change. You could hum the same tune you've hummed a thousand times, but stress, mood, alcohol, caffeine, medicine, and mental fatigue could change the electrical signals that are generated.

Chuang and his 16-year-old son, Gabriel Chuang, found that to be true in a study of exercise and passthroughs. As a science project for school, the father-son pair tested a passthrough system in 10 volunteers by giving them each a mental task before and after exercise. The pair found that it took up to 60 seconds for brain signals to return to normal after just 1 minute of jumping jacks. (Gabriel got an A.)

"The signals right after exercise are completely different from baseline," says Chuang. "So if you want to authenticate immediately after exercise, you will not be able to." The pair presented their study at the same IEEE conference in Orlando.

Despite advances in logging in with your mind, there might always be a need for an old-fashioned eight- plus character phrase with no spaces. "Passwords will never go away," says Chuang, who reasons that for a computer, a typed password may be the easiest way to verify identity, while a finger swipe may be best for a touch screen.

But we need to think beyond those to future devices—wearables, for instance—for which there will be neither a keyboard nor a touch screen. "For each device, we must figure out what are the most natural, intuitive ways to tell the device that we are who we are," Chuang says. Going directly to the brain seems like an obvious choice.

## Monkey Types 12 Words per Minute with Brain-Computer Interface

Posted 12 Sep 2016 | 22:00 GMT

IEEE Spectrum

By Eliza Strickland



Mage: Stanford University.

“To be or not to be. That is the question.” That is also the text that Monkey J typed out using a brain implant to control a computer cursor.

To be clear, the monkey didn’t know it was copying Shakespeare, and it had no deep thoughts about Hamlet’s famous monologue ([http://www.monologuearchive.com/s/shakespeare\\_001.html](http://www.monologuearchive.com/s/shakespeare_001.html)). Monkey J and its colleague, Monkey L, were both trained to use their neural implants to move a cursor over a computer screen, hitting circles as they turned green. Stanford University researchers placed letters on those targets to simulate the typing task. So to tap out the line from *Hamlet*, first the “T” circle was illuminated, then the “O,” and so on.

What was the point of this exercise? Was it simply an excuse to let journalists trot out the “infinite monkey theorem” ([https://en.wikipedia.org/wiki/Infinite\\_monkey\\_theorem](https://en.wikipedia.org/wiki/Infinite_monkey_theorem))? Because here we go: This probability theorem states that if you give a monkey a typewriter and infinite time, its random keystrokes will eventually produce the complete works of Shakespeare. (If you’d rather goof off than read about science, please enjoy these excellent cartoons ([https://www.google.com/search?q=infinite+monkeys&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjioPbLhYrPAhXMPB4KHdFtBWEQ\\_AUICigD&biw=1304&bih=645#tbm=isch&q=infinite+monkeys+s](https://www.google.com/search?q=infinite+monkeys&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjioPbLhYrPAhXMPB4KHdFtBWEQ_AUICigD&biw=1304&bih=645#tbm=isch&q=infinite+monkeys+s)).

No, the bioengineers had a more practical motivation. By simulating this typing task, they demonstrated that their brain-computer interface could greatly benefit people who can’t communicate otherwise. That category includes people in the late stages of amyotrophic lateral sclerosis (<http://www.alsa.org/about-als/what-is-als.html>) (ALS), also known as Lou Gehrig’s disease, which leaves the mind intact but gradually paralyzes the body, including the mouth and other face muscles.

This experiment set a new record for typing-by-mind, with one monkey tapping out 12 words per minute. “To our knowledge, this is the highest communication level ever achieved,” says Paul Nuyujukian (<https://npl.stanford.edu/~paul/>), a researcher at Stanford’s Neural Prosthetics Translational Lab (<http://med.stanford.edu/neurosurgery/research/NPTL.html>). Nuyujukian is coauthor of the paper (<http://ieeexplore.ieee.org/document/7564474/>) describing this research, published today in *Proceedings of the IEEE*.

Here’s how it works: The monkeys had tiny electrode arrays implanted in their brains, specifically in the part of the motor cortex ([http://thebrain.mcgill.ca/flash/d/d\\_06/d\\_06\\_cr/d\\_06\\_cr\\_mou/d\\_06\\_cr\\_mou.html](http://thebrain.mcgill.ca/flash/d/d_06/d_06_cr/d_06_cr_mou/d_06_cr_mou.html)) that controls arm movements. Those electrodes measured the electrical activity of neurons while the monkeys were trained at the cursor-control task, first moving their actual arms

while cameras carefully tracked the movements. Machine-learning algorithms found patterns in the stream of data, and translated those patterns into a monkey's intent to move the cursor left, right, up, and down.

Then the monkeys were set to the task of moving the cursor with their minds alone. (They could still make the movements in the air with their arms, but they weren't being tracked.) The computer picked up the same patterns in the brain data, and the cursor moved smoothly from target to target.

The prior record for brain typing, set by human patients with ALS last year, was 6 words per minute (<http://spectrum.ieee.org/the-human-os/biomedical/bionics/neural-implant-enables-paralyzed-als-patient-to-type-six-words-per-minute>). That experiment was done by a larger group of researchers, including Nuyujukian, who are part of the BrainGate (<http://www.braingate.org/>) consortium. The big improvement from that prior study came from software; the system used by the monkeys employed two smart algorithms in tandem, one to decode the cursor's movement (<http://www.nature.com/neuro/journal/v15/n12/full/nn.3265.html>), the other to decode the monkey's intent to click (<http://ieeexplore.ieee.org/document/7497003/?arnumber=7497003>) on a letter.

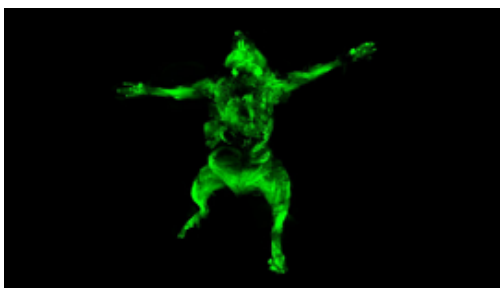
And there's plenty more room for improvement, Nuyujukian tells *IEEE Spectrum* in an interview. The monkeys used an interface in which they picked one letter at a time, he says, but future interface could borrow some tricks from smartphones. "I can imagine a smart interface that's auto-completing the words," he says. "Google and Apple have done a lot of work on how to maximize the input from our very inaccurate thumbs. We can leverage a lot of that."

Human trials of the technology are already underway. In one experiment, which the researchers presented at a conference (<http://www.abstractsonline.com/plan/ViewAbstract.aspx?cKey=717decbc-7c8b-47c5-a024-170ada5a2847&mID=3744&mKey=d0ff4555-8574-4fbb-b9d4-04eec8ba0c84&sKey=c82a451a-073f-4250-aca1-e0d00b2f9192>) last year, a woman with ALS used the cursor-control system with an Android tablet, using it to browse the web and write emails. Such human studies make it clear that the researchers aren't just trying to generate a wave of jokes about Shakespearean monkeys. They're trying to give paralyzed people their autonomy and the ability to speak their minds.

But the researchers aren't above having a little fun themselves. Nuyujukian divulged some of the early phrases they had the monkeys type out as they tested the system: "A banana, a banana, my kingdom for a banana!" and "A banana by any other name would smell as sweet."

## Mouse's Body Made Entirely Transparent to Reveal Nervous System

New Scientist  
DAILY NEWS 22 August 2016



By Andy Coghlan  
Is it a ghost, a shaman or a dead,  
transparent mouse?  
Ali Ertürk

Behold the entire nervous system of a mouse, revealed in unprecedented detail by turning the animal's body completely transparent. This technique could help us better understand the workings of mammal brains and bodies.

Ali Ertürk of the Ludwig Maximilian University of Munich in Germany and his team have refined a technique called tissue clearing, so that the whole bodies of mice and rats can be studied in more detail than ever before. Other methods exist for making transparent rodents, but Ertürk's technique also shrinks the body to around a third of its original size, making it possible to view the whole animal under a microscope, and subject it to detailed laser scanning for the first time.

This enabled the team to image all the nerve cell connections inside a mouse from head-to-toe, a feat never before accomplished, says Ertürk. "We imaged the complete central nervous system of mice, and you can track individual cells several centimetres long that reach from the brain right through to the tip of the spinal cord," he says. Projection allows researchers to travel virtually through the mouse, examining all its neural connections.

The technique involves using a solvent to wash out all of a dead animal's body water, and much of its fat too, over three or four days. This leaves the remaining tissue, including the bones, transparent, enabling much clearer, crisper microscope images.

By taking many laser scans and putting these images together, the team generated a 3D projection of a mouse, with its nervous system illuminated by a glowing green protein.

Ertürk's team is using the technique to study how traumatic brain injuries in mice affect the central nervous system.

The team has already scaled the technique up for rats, which are 10 times the size of mice. "It might be possible with larger animals, such as small monkeys, and possibly a whole human brain for the first time in the near future," says Ertürk.

Being able to examine deep inside human brains after death without cutting into them could be a crucial step in understanding the brain's connectome – the entirety of its neural circuits. The hope is that comparing the connectome of a healthy person with those of people with disorders like Alzheimer's disease, multiple sclerosis or schizophrenia, could help us understand exactly how these conditions affect the brain.

Journal reference: *Nature Methods*, DOI: 10.1038/nmeth.3964

## **Position-Independent Decoding of Movement Intention for Proportional Myoelectric Interfaces**

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**DOI: 10.1109/TNSRE.2015.2481461**

**Ki-Hee Park Heung-Il Suk, Seong-Whan Lee**

In this decade, myoelectric interfaces based on pattern recognition have gained considerable attention thanks to their naturalness enabling human intentions to be conveyed to and in control of a machine. However, the high variations of electromyogram signal patterns caused by arm position changes prohibit application to the real world. In this paper, we propose a novel method of decoding movement intentions robust to arm position changes towards proportional myoelectric interfaces. Specifically, we devise the position-independent decoding that estimates the likelihood of different arm positions, which we predefine during a training step, and also decodes the movement intention in a unified framework. The proposed method has an advantage that could be used to decode the movement intentions on untrained arm positions in a realistic scenario. Our experimental results showed that the proposed method could successfully decode the continuous movement intentions (e.g., flexion/extension and radial/ulnar deviation) on both trained and untrained arm positions. Our study also proved the effectiveness of the proposed method by comparing the existing methods in terms of the decoded trajectories as movement intentions in untrained arm positions.

## New Startup Aims to Commercialize a Brain Prosthetic to Improve Memory

IEEE Spectrum

By Eliza Strickland

Posted 16 Aug 2016 | 18:00 GMT

A startup named Kernel (<http://kernel.co/>) came out of stealth mode yesterday and revealed its ambitious mission: to develop a ready-for-the-clinic brain prosthetic to help people with memory problems. The broad target market includes people with Alzheimer's and other forms of dementia, as well as those who have suffered a stroke or traumatic brain injury.

If the company succeeds surgeons will one day implant Kernel's tiny device in their patients' brains—specifically in the brain region called the hippocampus (<https://en.wikipedia.org/wiki/Hippocampus>). There, the device's electrodes will electrically stimulate certain neurons to help them do their job—turning incoming information about the world into long-term memories.

Kernel's device will be based on a research effort led by Ted Berger (<http://bme.usc.edu/directory/faculty/core-faculty/theodore-w-berger/>), director of the Center for Neural Engineering at the University of Southern California. Berger tells *IEEE Spectrum* that his experiments with rats and primates make him confident that “it's really time” for a clinical device. “We're testing it in humans now, and getting good initial results,” he says. “We're going to go forward with the goal of commercializing this prosthesis.”

Berger's pioneering work on memory prosthetics was featured in an *IEEE Spectrum* article (<http://spectrum.ieee.org/biomedical/bionics/we-will-end-disability-by-becoming-cyborgs>) reporting on attempts to end all physical, emotional, and intellectual disabilities.

In Berger's approach, electrodes in the hippocampus first record electrical signals from certain neurons as they learn something new and encode the memory. These electrical signals are the result of neurons “firing” in specific patterns. Berger studied how electrical signals associated with learning are translated into signals associated with storing that information in long-term memory. Then his lab built mathematical models that take any input (learning) signal, and produce the proper output (memory) signal.

An implanted memory prosthetic would have electrodes to record signals during learning, a microprocessor to do the computations, and electrodes that stimulate neurons to encode the information as a memory.

For people who have difficulty forming lasting memories on their own, the prosthetic would provide a boost. “We take these memory codes, enhance them, and put them back into the brain,” Berger says. “If we can do that consistently, then we'll be ready to go.”

Prior research on memory prosthetics by both Berger and other neural engineers has received funding from DARPA, which also aims to develop a clinical device within the decade (<http://spectrum.ieee.org/biomedical/bionics/darpa-project-starts-building-human-memory-prosthetics>).

## Do “Brain-Training” Programs Work?

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In 2014, two groups of scientists published open letters on the efficacy of brain-training interventions, or “brain games,” for improving cognition. The first letter, a consensus statement from

an international group of more than 70 scientists, claimed that brain games do not provide a scientifically grounded way to improve cognitive functioning or to stave off cognitive decline. Several months later, an international group of 133 scientists and practitioners countered that the literature is replete with demonstrations of the benefits of brain training for a wide variety of cognitive and everyday activities. How could two teams of scientists examine the same literature and come to conflicting “consensus” views about the effectiveness of brain training?

In part, the disagreement might result from different standards used when evaluating the evidence. To date, the field has lacked a comprehensive review of the brain-training literature, one that examines both the quantity and the quality of the evidence according to a well-defined set of best practices. This article provides such a review, focusing exclusively on the use of cognitive tasks or games as a means to enhance performance on other tasks. We specify and justify a set of best practices for such brain-training interventions and then use those standards to evaluate all of the published peer-reviewed intervention studies cited on the websites of leading brain-training companies listed on Cognitive Training Data ([www.cognitivetrainingdata.org](http://www.cognitivetrainingdata.org)), the site hosting the open letter from brain-training proponents. These citations presumably represent the evidence that best supports the claims of effectiveness.

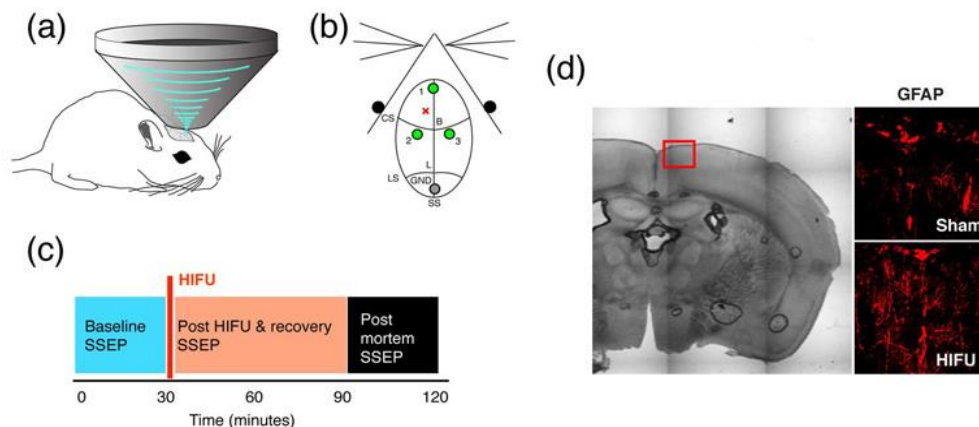
Based on this examination, we find extensive evidence that brain-training interventions improve performance on the trained tasks, less evidence that such interventions improve performance on closely related tasks, and little evidence that training enhances performance on distantly related tasks or that training improves everyday cognitive performance. We also find that many of the published intervention studies had major shortcomings in design or analysis that preclude definitive conclusions about the efficacy of training, and that none of the cited studies conformed to all of the best practices we identify as essential to drawing clear conclusions about the benefits of brain training for everyday activities. We conclude with detailed recommendations for scientists, funding agencies, and policy makers that, if adopted, would lead to better evidence regarding the efficacy of brain-training interventions.

## Real-Time Detection and Monitoring of Acute Brain Injury Utilizing Evoked Electroencephalographic Potentials

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Rapid detection and diagnosis of a traumatic brain injury (TBI) can significantly improve the prognosis for recovery. Helmet-mounted sensors that detect impact severity based on measurements of acceleration or pressure show promise for aiding triage and transport decisions in active, field environments such as professional sports or military combat. The detected signals, however, report on the mechanics of an impact rather than directly indicating the presence and severity of an injury. We explored the use of cortical somatosensory evoked electroencephalographic potentials (SSEPs) to detect and track, in real-time, neural electrophysiological abnormalities within the first hour following head injury in an animal model. To study the immediate electrophysiological effects of injury *in vivo*, we developed an experimental paradigm involving focused ultrasound that permits continuous, real-time measurements and minimizes mechanical artifact. Injury was associated with a dramatic reduction of amplitude over the damaged hemisphere directly after the injury. The amplitude systematically improved over time but remained significantly decreased at one hour, compared with baseline. In contrast, at one hour there was a concomitant enhancement of the cortical SSEP amplitude evoked from the uninjured hemisphere. Analysis of the inter-trial electroencephalogram (EEG) also revealed significant changes in low-frequency components and an increase in EEG entropy up to 30 minutes after injury, likely reflecting altered EEG reactivity to somatosensory stimuli. Injury-induced alterations in SSEPs were also observed using noninvasive epidermal electrodes, demonstrating viability of practical implementation. These results suggest cortical SSEPs recorded at just a few locations by head-mounted sensors and associated multiparametric analyses could potentially be used to rapidly detect and monitor brain injury in settings that normally present significant levels of mechanical and electrical noise.

## **The Unique Evolutionary Signature of Genes Associated with Autism Spectrum Disorder**

**Behav Genet. DOI 10.1007/s10519-016-9804-4**

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Autism spectrum disorder (ASD) is a common heritable neurodevelopmental disorder, which is characterized by communication and social deficits that reduce the reproductive fitness of individuals with the disorder. Here, we studied the genomic characteristics of 651 ASD genes in a whole-exome sequencing dataset, to search for traces of the evolutionary forces that helped maintain ASD in the human population. We show that ASD genes are >65 longer and >20 % less variable than non-ASD genes. The mutational shortage in ASD genes was particularly eminent when considering only deleterious genetic variations, which is a hallmark of negative selection. We further show that these genomic characteristics are unique to ASD genes, as compared with brain-specific genes or with genes of other diseases. Our findings suggest that ASD genes have evolved under complex evolutionary forces, which have left a unique signature that can be used to identify new candidate ASD genes.